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COAL WASHING.

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IMPURITIES OF COAL.

A perfectly pure seam of coal, that is of coal which leaves by combustion an insignificant amount of ash, is very rarely found.

If we consider the origin and formation of coal, it will be seen that, besides the incombustible materials contained in wood and vegetable fibre, and which are, in part at least, found in the coal, there are many impurities foreign to these, which are introduced during the process of transformation of woody fibre into coal.

Whether a coal seam is derived from vegetation *in situ* or from *drifted* vegetation, the addition of foreign sedimentary matter, formed in successive deposits from the water holding it in suspension, is almost universally observed.

The denomination of *splent* coal, given to a hard laminated variety of bituminous coal, is derived from its splitting or *splenting* into separate laminæ, arising from its mode of formation. Of the structure of the Appalachian coal, which covers such a large area in the United States, Professor Roger says: "Each bed is made up of innumerable very thin laminæ of glossy coal, alternating with equally minute plates of impure coal, containing a small admixture of finely divided earthy matter."

An examination of a series of tables showing the composition of the ash of wood, peat, lignite, coal, and graphite, is instructive.

The ash of wood reveals by analysis the presence of sulphates and phosphates of lime and oxide of iron in moderate proportion, of a large amount of lime, magnesia, and potassa, and of a very little silica, alumina, soda, oxide of manganese. The ash of peat and of lignite contains the same elements, but a change is observed in their relative proportions. The amount of potassa is found to have diminished, whilst silica, oxide of iron, alumina, and sulphur have increased. The ash of many coals has been analyzed. It contains in general a large proportion of silica, alumina, oxide of iron, sulphur, with a greatly diminished amount of lime and magnesia.

Finally, the ash of various graphites is found to consist generally of as much as 90 per cent. of silica and alumina, and 6 to 10 per cent. of oxide of iron, with a small amount of lime, magnesia, and alkalies.

The gradual and continuous change in the nature of the ash confirms the theory which attributes most of the impurities of coal to foreign sedimentary deposits, for we observe a gradual diminution of these elements of the ash of plants, which, like the alkalies, are very soluble or enter easily into soluble combinations, and, on the other hand, an increase of elements,

such as silica, alumina, and iron, which enter largely into the composition of clays and of most soils.

Even the best mineral coal reveals by analysis traces of sulphur. The sulphur smell ordinarily perceived in coal fires is owing to this. The sulphur is found in combination with iron, forming pyrites, or in the shape of sulphate of lime, magnesia, etc., in scales. The pyrites are disseminated in coal beds in nodules or seams of great tenuity. They are sometimes so small as to be invisible to the naked eye, although abundant. At other times the yellow crystals of pyrites or bi-sulphide of iron are visible. By exposure to air, yellow spots appear on the surface of certain coals; these are due to the oxidation of the pyrites. The water in some coal mines is so highly charged with sulphate of iron as to be very destructive to rails and boilers. The red color of the ash of many coals is due to the presence of oxide of iron, which comes chiefly from the pyrites.

Besides the above impurities, bituminous schist, arsenical pyrites, carbonate of iron, in scales, are found. Accidentally various other metallic sulphides, galena blende, copper pyrites, sulphide of mercury, have been found. Rivot has detected the presence of a heavy proportion of phosphate of iron in some bituminous schists which accompany coal.

All these impurities which exist in the coal in the shape of bands or scales generally apparent to the eye, constitute the ashes and clinker left by combustion. The chief source of clinker is the carbonate of lime and pyrites.

Besides the impurities contained in the coal seams, most coals when ready for market contain fragments of wall rock which become mixed with it during the operation of mining. When the wall rock, or strata immediately contiguous to the coal, is friable, these fragments are often in such abundance as to injure seriously the quality of the coal.

ADVANTAGES OF COAL WASHING.

When a coal basin produces coal which contains but a small average percentage of ash, and when, at the same time, there is but little slate or schist interstratified in the coal seams, and when the roof and wall rocks are firm and solid, it frequently happens that the coal on leaving the mine is sufficiently clean to be delivered at once for consumption. This is oftener the case in England than in France, where coal washing has been first practised on an extensive scale; but it is also true that the advantages of using pure fuel have been the better appreciated by the consumer in France.

The first trials of coal washing were made some thirty years ago at St. Etienne; to-day the operation is carried on by hundreds of thousands of tons, and usually accompanies the manufacture of coke, of pressed fuel, or the use of raw slack coal.

A simple calculation shows that when the price of coal is at all high the consumer will find it to his interest to pay for the cost of washing. Some industries demand imperatively the use of pure fuel.

The injurious action of the sulphur contained in the fuel used in blast furnaces for smelting iron or in puddling furnaces need not be dwelt upon.

Many coals when deprived of their impurities will coke, although they cannot be coked without washing; the quality of every description of coke may be greatly improved; different qualities of caking and non-caking coals may be *mixed*, purified, and coked, thus incorporating non-caking coals into solid coke.

Carbonate of lime and pyrites, the principal sources of *clinker*, are removed by washing, so that the clinker may be greatly reduced. The labor in attending boiler fires due to the presence of clinker may be spared. Whenever the transportation of coal is expensive, as in steamers, the removal of 10 per cent. or more of ash is a serious consideration.

This industry is also important to gas companies, for gas free from sulphur and a more valuable coke may be produced. In the manufacture of brick-coal or patent fuel, the operation of washing allows the use of inferior slack coal, and gives a better product.

Much of the bituminous coal of Pennsylvania and Ohio is impure. The Illinois coals contain 1 to 37 per cent. of ash (Geological Report), and the joints are sometimes filled with foreign matter containing much sulphur. To the impure coals of these and other States will the coal-washing operation be of particular benefit.

Many seams of coal containing impurities mechanically mixed are at present discarded for purer seams which lie deeper

beneath the surface or at greater distances from market. The coal of those seams can be thoroughly cleansed of these impurities by a proper washing process, and it will then become merely a question of cost of washing per ton, against diminished mining and freight expenses on account of a more available location and proximity to market, to render many of these impure seams as valuable and even more profitable than purer ones.

The cost of coking, which limits so seriously the value of many coal seams, is susceptible of great reduction. The methods of coking hitherto practised in America give very inferior economic results when compared to European processes. This arises from the improper construction of our coking ovens, and, singularly enough, from the lack of labor-saving apparatus, in both of which there is room for simple improvements. With regard to coal washing, the "London Engineer" says:

"Coal washing, however, is not as yet sufficiently known and appreciated in this country (England). Continental collieries are far in advance in this respect, and a great deal could be learned and *must* be learned from them by our coal-masters before long."

SEPARATION OF THE IMPURITIES BY WATER.

In the separation of the impurities contained in coal by the action of water, this liquid acts in three different ways: By *differences of specific gravity*, by *solution*, and by *mechanical mixture*.

1st. By the last is understood an intimate mixture of a liquid and fine particles of matter, which are not, properly speaking, *dissolved*, but merely carried mechanically in suspension, and which will generally deposit themselves when the liquid is at rest. The matter separated in this way, forms a "slime" or "schlamm," which consists of a considerable amount of very fine coal together with many particles of fine clay, shale, and earthy ingredients. When this slime is collected in proper deposit basins and dried, it can be used as inferior fuel, thus economizing the fine coal dust which is usually lost.

2d. The substances separated from coal by *solution* in water are many, as coal is completely insoluble. What these substances are may be readily seen by inspecting a table of solubility. All sulphates, for instance (with the exception of those of BaO, SrO, PbO, not often met with in coal), are soluble in water, so that the separation of those injurious substances and of others by solution, affords a ready means of purification.

3d. The chief action depended on, however, in coal-washing machines is the difference between the specific gravity of coal and its impurities. The specific gravity of coal and lignite varies from 1.2 to 1.46, water being 1.0, while that of the impurities is considerably greater, as follows:

Clay slate (specific gravity)...	2.6
Mica slate.....	2.6 to 2.9
Limestone and dolomite.....	2.5 to 3.0
Sand, quartz.....	2.6 to 2.7
Phosphate of lime.....	2.7 to 3.3
Carbonate of iron.....	3.7 to 3.9
Iron pyrites, yellow and white.	4.7 to 5.0

As the impurities of coal are completely disseminated throughout the mass, it must first be crushed sufficiently to allow them to be separated. When a mass of slack or crushed coal is submerged in water in motion, all the clean coal, being lightest, finds its way to the upper layers, while the impurities, being heaviest, accumulate below.

The form and size of the fragments have a great influence on the separation. The resistance which a liquid medium opposes to bodies moving through it, impelled by a given force, is proportional to the *surface* which they present; and for bodies presenting the same surface, the velocity increases with the *weight*. Now, the weights of two bodies of same form and density are *as the cubes* of one of their dimensions, while the surfaces are *as the squares*. It is then clear that, to effect an easy separation by specific gravity, the bodies to be separated should be of the same size and form.

It is easy by the use of proper sizing apparatus to obtain fragments of uniform size, and thus to realize the first condition which is essential to perfect and prompt separation.

With many coals no other precaution than sizing is necessary, as they have a natural tendency to be reduced by crushing into *cubical* fragments, consequently of the same form. But other coals are of a slaty nature, or abundantly interstratified with thin seams of shale, schist, slate, etc.

When these coals are crushed the pure parts break up into small cubes, but the impure parts and the thin layers of shale and schist break up into *flat* fragments. A simple fall through water will not separate these bodies, even when uniformly sized, for, the impelling force being the weight, the weight of a cubical fragment of pure coal will often exceed that of a flat fragment of shale presenting the same surface and greater density. An additional means of separation is then required, and is obtained by the use of a *lateral* or nearly horizontal current imparted to the water as in *step-washing* and in some other machines. This horizontal current separates the cubical coal from the flat shale for two reasons: the coal presents more surface to the action of the current than the shale, which presents its thin edge to the stream; this, together with its greater weight, promptly deposits the shale, while the coal is carried away. From inattention to this requirement disappointments have sometimes arisen, which might have been obviated by the choice of a machine adapted to the nature of the coal.

A further advantage derived from properly sizing the coal, arises from quicker washing. The production of a "jigging machine" is proportioned to the *number of effective strokes* per minute. To be effective, each stroke must last long enough to give the impurities time to settle. This time is shorter, and also more uniform, when the fragments are all of equal size.

CRUSHING AND SIZING.

To effect a perfect separation it is necessary then to crush and size the slack coal before washing. This operation is practised in many coal-washing establishments, and is particularly required when the coal is slaty.

In crushing, it is desirable to produce the least quantity of stuff finer than is intended, for this dust obstructs the crushers, and allowance must be made for the presence of hard stones in the coal. The coffee-mill principle is not well adapted to fulfil these conditions. Crushing rollers, geared together, do not work well unless the teeth are sufficiently long to allow of a variable space between the cylinders; the play thus allowed produces loss of power by friction. It is best to use crushing rollers commanded by separate belting for each. These rollers, as in Bérard's machine, are grooved in two directions, forming rows of quadrangular teeth with rounded tops, which break up the schist effectively. In Bérard's machine, one of the cylinders is free, and held by a spring. A large diameter increases the hold of the crushers. A pair of cylinders of 20 in. diameter, 36 in. long, making 60 revolutions per minute, will crush 10 tons of coal per hour.

The crushing rollers may be maintained in contact as in the rollers for crushing ores, either by screws, a lever and a counterweight, or by springs of metal or india-rubber. The first method is objectionable and causes breakages. The second works very well in Cornwall. Bérard uses the third. A system has been devised by Mackworth, in which the rollers are conical and connected by a number of india-rubber bands strongly stretched. A compound cord of india-rubber 3 in. in diameter composed of 144 small cords when stretched to double its natural length gives a strain of 3 tons, which is exerted to keep the rollers in contact. The coal is supplied to the rollers from a feed hopper.

The *sizing* is performed by passing the coal through sieves, which are either cylindrical as in the *sizing trommel*, or plane, as in the *swing sieve*. The trommels do not perform much work, unless their diameter is considerable; an increase of velocity produces adhesion of the coal to the sieve and performs less work. Shaking sieves, strongly inclined and superposed, are better adapted to a large production. The sieves are made of wire or of punched screens, that is, perforated metallic plates. Evrard has perfected a system of horizontal annular sieves which turn on a vertical shaft; the coal is swept off each sieve by stationary curved arms.

A size of 0.7 to 0.8 in. in diameter is well adapted to washing. The size, however, should be determined in each particular case by the use to which the coal is to be put, and by its tendency to form a paste.

PRINCIPLE OF COAL-WASHING MACHINES.

We have seen that the difference between the specific gravities of coal and its impurities, and the solubility of some of these, allow of their being separated *by the action of water*, when they are reduced

to a proper size. Machines for washing coal may be divided into different classes according to the mode of action of water in each.

First class.—The coal is submitted to *a continuous stream* of water upon inclined tables, as in the *step-washing* of ores. The tables are inclined against the stream and arrest the heavier impurities, while the clean coal, being lighter, is carried on to a platform where it is deposited and the water drained off.

Second class.—The mode of action in this class of machines consists in forcing the water *alternately up and down* through the mass of coal as in the *jigging process* for washing ores. The coal is charged upon a sieve, and the water acts upon the coal from below through the sieve. The jigging motion is imparted by hand or machine, either to the water, in which case the sieve is stationary, or to the sieve while the body of water remains stationary, as in the jigging machines first used for ores. In either case the stones and denser bodies remain on the sieve while the coal accumulates above and is carried off, either by a stream of water devoted to that purpose, by laborers who shovel it away, or by various mechanical devices. The impurities which accumulate upon the sieve are removed at given intervals of time in various ways.

Third class.—In these machines *an intermittent stream* of water, *constant in direction*, acts upon the coal from below, through a sieve. In the jigging process the water *oscillates* and returns upon itself at every stroke, while in the third class of machines the water never retraces its steps, and the motion is properly *pulsatory*. The requisite pulsatory motion is generally obtained by a pump.

Fourth class.—The coal is submitted to a slow and *continuous upward stream* of water, which, aided by a rotating arm, carries the clean coal out upon a perforated plate where it is drained, while the shale and dense impurities fall slowly through the ascending current of water, and accumulate in a shale box, where they are evacuated. The stream of water acts vertically in this class, while in the first class it acts horizontally.

The Bérard, Revollier, Kladno, Edwards and Beacher, and Evrard machines belong to the second class.

The Meynier, Ractmadoux and Coppée machines belong to the third class.

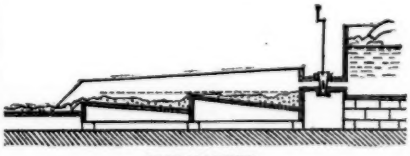
Mackworth's machine is of the fourth class.

For much of the following information relating to these machines, I am indebted to Mr. Burat, Professor at the Ecole Centrale des Arts et Manufactures, and to various papers on the subject by Messrs. Lebleu, Petitgand, Ronna, Darlington, etc.

STEP-WASHING.

(Caissè à eau Courante, Washerde.)—In 1838 Ractmadoux described a method then used at the mines of Bert, and which, as far back as 1826, was used in the valley of Tarand, near Dresden, for purifying slack coal. A continuous stream of water from a superior reservoir is directed upon a flat chest, the bottom of which is formed of two steps inclined 1.5 in. per ft. against the stream. The second step is lower than the first, and is

FIG. 1.



STEP-WASHING.

succeeded by a table of wickerwork, or a perforated metallic sheet, upon which the cleansed coal is drained. A low flat board across the upper end of each step serves as a dam to arrest the slate, stones, and denser bodies; when these have accumulated sufficiently upon the steps, the washing is interrupted for a moment and they are shovelled away.

The above cut and the succeeding ones are reduced from more complete drawings, and merely illustrate the principle of the various machines.

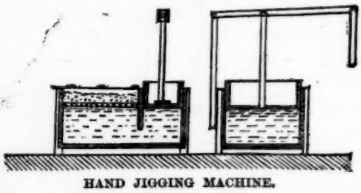
HAND JIGGING MACHINE.

The jigging process was applied to purifying coal at the St. Etienne collieries as early as 1837. The coal of this basin in the centre of France is so frequently interstratified with slates, etc., as to require imperatively to be cleansed.

A wooden hutch or chest, measur about 4 by 6 ft. and 3 or 4 ft. high, is

divided into two compartments. In the first compartment a rectangular wooden piston measuring 2 by 4 ft. is acted upon through a piston rod and hand lever; this piston communicates an oscillating

FIG. 2.



HAND JIGGING MACHINE.

movement to the water under it, which is at once transmitted through a rectangular side opening 1 by 4 ft. to the water in the second compartment. Across the second compartment, about 6 in. from the top, is a sieve or grating, upon which the coal is charged. The area of this sieve is double that of the piston, or 4 by 4 ft.

Successive charges of coal are made upon this sieve, cleansed by jigging, and shovelled from the surface. After several charges, the sieve is taken out and the refuse slates, etc., which have collected upon it, are thrown away. One man can wash $\frac{3}{5}$ to $\frac{1}{2}$ a ton per day of 10 hours in this machine, which is particularly adapted to very slaty and impure coals. It will be shown later how Revollier imitates the peculiar hand motion of this machine.

BERARD'S MACHINE.

This machine belongs to the second class. In 1848 Mr. Bérard invented a somewhat complicated machine, which has since been simplified into its present form.

It consists of a pair of crushing rollers, an elevator formed of an endless chain with buckets, a classifier formed of shaking tables, a cistern and piston, an agitator, a chest for deposits, and water tanks.

A power of 5 to 6 horses is required by the apparatus, which will purify 80 tons of coal per day of 12 hours. The slack coal used is passed through the crushers, which are provided with cast-iron coverings grooved in two directions so as to form a number of quadrangular teeth with slightly rounded tops. These double grooves break up the slate contained in the coal more effectively than single grooves would. The distance between the rollers can be altered to suit the hardness of the coal.

From the crushers the coal falls into a pit of masonry formed like an inverted quadrangular pyramid, three faces of which are inclined at 45 deg., and the fourth vertical. The buckets of the elevator carry this crushed coal to a higher level and discharge it into the classifier. So as to obtain regularity of feed, the buckets as they rise pass close to a board which equalizes their contents and throws the excess of coal back into the pit.

The classifier, which receives the coal from the buckets, is a rectangular sheet-iron chest containing stages of perforated plates, the apertures in which are 0.8 to 1.2 in. in diameter, and decrease in a downward direction. A shaking motion is imparted to these tables through a cam movement, or a rapid reciprocating motion is produced by a direct connection with a bent axle, commanded by cog gearing. The classifier is freely suspended by two or three pair of articulated handles turning on fixed axles.

The fine coal which has passed through the classifier falls into the washing cistern, whilst the larger pieces return along an inclined channel to the crusher.

The washing cistern consists of a rectangular cast-iron chest, the bottom of which is mostly inclined at 45 deg. A cast-iron frame is firmly fixed near the top of the cistern with a slight inclination of 3 in 100. Across this frame is secured a perforated plate made either of zinc or copper. The size of the holes varies according to the kinds of coal.

Upon one side of the cistern is bolted a vertical cast-iron cylinder, the bottom of which is curved so as to place the cylinder in communication with the cistern through an aperture in its side. A piston fitting into this cylinder receives a rapid reciprocating motion, imparting an upward and downward "jigging" motion to the water in the cistern, which acts through the perforated plate upon the impure fine coal, carrying the pure coal upwards, and separating the denser impurities. These accumulate upon the grate, and by means of a partition and small flood-gate these schists, pyrites, etc., are discharged into a pocket from whence they can be emptied into wagons. The pure coal carried upwards at each stroke

flows over one edge of the cistern into a trough, where a chain and buckets elevate it and discharge it into a hopper. This hopper is at a sufficient height to allow the coal to be delivered through a bottom door into cars.

A man-hole is provided on one side of the cistern, and an opening at the foot of the inclined bottom, through which the mud which accumulates there can be emptied.

A separate feed pump supplies the cistern with a determined amount of water.

Bérard's machine is used in many localities in France, Belgium and Germany, also in England at the Whitehaven and Fence-Houses collieries. It is somewhat complicated, and has been improved upon.

The first cost of the machine to produce 80 tons a day is in France $4,400 gold. Add masonry, water pipes, belts, sheds, for $2,000 more. Total, about $6,400. The direct cost of washing, including labor of 1 man and 1 boy, oil, repairs, and interest on first cost, is estimated at 5 cts. per ton.

The loss produced by the percentage of impurities varies with the coal.

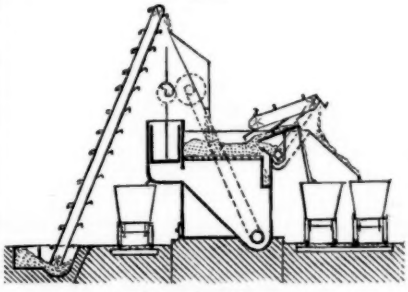
REVOLLIER'S MACHINES.

Mr. Revollier, known for his coal-pressing machine, has also perfected two coal washing machines, analogous to Bérard's, and acting by the jigging process.

First Machine.—The piston is of wood and square instead of round, and fits loosely in its box. The washing cistern is made of sheet-iron, and presents two compartments; a bucket and endless chain plunges into the coal compartment and extracts the clean coal; a wheel and buckets removes the schist through a side opening. The same water is used over many times.

Second Machine.—This machine is an improvement on the preceding one, and on Bérard's. The sorter of Bérard is suppressed. An endless chain and buckets raises the slack coal 20 ft. from a pit and discharges it into a hopper over the washing cistern. The surface of perforated sheet measures 38 by 56 in. The coal slack cleansed is separated into two qualities; the upper or first quality is raked off the surface by an endless chain with rakes, and falls into a shoot 4 ft. long, which discharges it into a car. The second quality of coal coming from the medium level of the washed mass, runs over the edge of the cistern into a trough, where a horizontal screw carries it to a small bucket elevator which raises it 6 ft. and empties into a shoot leading to a car. Finally the schists and impurities pass from the lowest level of the washed mass into an inclined pocket, at the foot of which a screw carries them horizontally to a bucket elevator which raises them 12 ft. and discharges them into a car. The total surface occupied by the apparatus is comprised within an area of 8 by 25 ft. The amount of coal washed per day is 60 tons.

Fig. 3.



REVOLLIER'S MACHINE.

These machines are used in the centre of France, in the basin of the Loire; the coals of this basin are more impure and harder to clean than those of Belgium and the Northern basin. To separate these very slaty coals the *hand jigging* process is the most effective, as the intensity of the jigging can be readily varied to suit the separation. Thus at the start the layer of coal should receive a sudden and rapid impulse which carries the coal and schist upwards, whilst the stroke is then slackened, and the schist settles slowly down and the coal remains in suspension.

Mr. Revollier imitates this motion by giving a height of 30 in. and considerable weight to the piston. The piston is raised slowly by a pair of eccentric cams and falls back suddenly, impelled by its own weight, and sometimes by a spiral spring. This gives the sudden impulse required to the water. The diameter of the piston is 30 in., and it fits loosely in the cylinder.

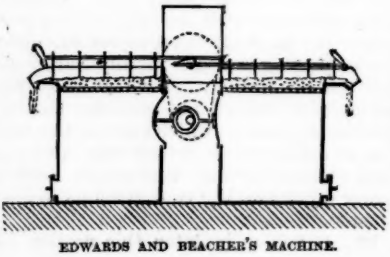
KLANDO MACHINE.

Also of the second class. At the Kladno Iron Works, Austria, the coal is purified by washing on a large scale. After being ground in a species of enlarged coffee mill to a fine powder, the coal dust is discharged into an inclined sieve which sorts the different sizes and discharges them upon a series of rocking sieves placed in water tanks. The rocking motion of these sieves alternately brings the layers of coal spread upon them above and below the water and effects the separation as in the jigging process. A constant current of water, kept running through the whole apparatus, carries away the finest dust and "schlamms" from the coal, and deposits them in a slime basin, as in Coppée's apparatus, while the clean coal is removed from the upper layers on the sieves. It will be observed that in this machine the body of water is comparatively stationary, whilst the sieves receive the jigging motion as in the first jigging machines devised for washing ores.

EDWARDS AND BEACHER'S MACHINE.

Belongs to the second class. In this machine two rectangular cisterns are placed upright a few feet apart. On the sides of the cisterns facing each other are two circular apertures closed by flexible discs or diaphragms of leather, to which a horizontal reciprocating motion is imparted by means of an eccentric on a

Fig. 3.



EDWARDS AND BEACHER'S MACHINE.

horizontal shaft. This shaft is driven by a belt and pulley, or by a steam-engine attached directly to it. The action of the flexible diaphragms imparts to the water in the cistern the requisite jigging motion.

Across the upper end of the two cisterns are stretched perforated plates upon which the coal to be cleaned is fed through a hopper, which also connects the two cisterns.

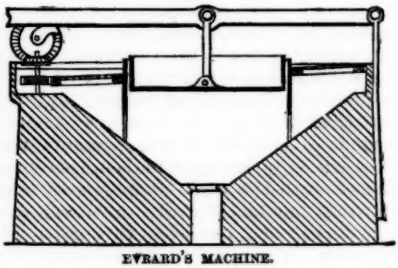
Above the driving shaft is a smaller one driven at a slower rate by cog gearing; eccentrics or cranks communicate a horizontal reciprocating motion to a set of scrapers above each cistern. These are so arranged as to remove the upper stratum of coal, which is the cleansed portion, and discharge it over the edge into cars. When the schists, pyrites, etc., have accumulated on the screens to a sufficient depth, the scrapers are thrown out of gear, and these impurities are raked off. One machine of two connected cisterns will wash 30 tons of coal per diem.

EVRARD'S MACHINE.

Belongs to the second class. This machine is a modification of the preceding one and adapted to operate at once upon a larger quantity of coal. Mr. Evrard gives to the sieve the form of a ring of 33 ft. exterior and 19.6 ft. interior diameter.

This annular sieve is placed across the top of a conical basin built up with solid masonry walls. The centre of the ring is occupied by a vertical cast-iron cylinder, in which fits loosely a hollow cylindrical piston 18.4 ft. in diameter. The surface

Fig. 4.



EVRARD'S MACHINE.

of the piston is 270 square ft., or just one half that of the annular sieve. This sieve is not horizontal, but inclines 3 in 100; so that whilst the upper end is 2 in. above the level of the water in the basin, the lower end dips 10 in. below the level.

The fine coal is charged upon the upper end of the sieve through a hopper opening a few inches above the water level. A rotary motion of one revolution in 5 minutes is imparted to the sieve, so

that in this interval of time the coal is carried slowly through the water and is submitted to the jigging process at depths varying successively from 0 to 10 in. and back again to 0. As the coal emerges from the water towards the end of the turn, it is scraped off by a series of curved stationary arms. The first pair of arms takes off 1.5 in. of the surface coal, which is cleanest, and does not contain more than 3 or 4 per cent. of ash. The second pair of arms dips 3 in. under water, or deeper than the first, and collects a medium quality of coal containing about 6 per cent. of ash. The third pair of arms is movable, and dips 3 to 4 in., removing a layer consisting of an intimate mixture of coal and schists of very variable percentage of ash. Finally, the fourth pair of arms, also movable, scrapes the bottom of the sieve and removes the stones, schist, etc., which have accumulated during a number of revolutions. Whenever the deposits of stone and schists attain a thickness of 2 in. they appear at the third pair of arms, which are then thrown out of gear, and the fourth pair is brought into play. One man attends to these arms and to loading the refuse in cars.

The bottom of the basin is in the shape of an inverted cone. A bottom door allows the slime which accumulates there to be dropped into cars moving on rails, in a gallery running through the masonry. The sieve is made of perforated metallic sheets fastened to an iron frame; the outer rim is provided with cogs; two pinions of equal size command the circular rack, so that if one pinion breaks, the operation is not interrupted. Conical horizontal rollers and cylindrical vertical ones maintain the sieve in its place. All these organs are submerged in water and wear out very slowly.

The piston is commanded by a lever 40 ft. long and an eccentric cam, and gives 20 strokes a minute.

A 4-horse power engine moves the sieve and piston. A second engine also of 4-horse is required for the sorter, and bucket elevator which supplies the hopper.

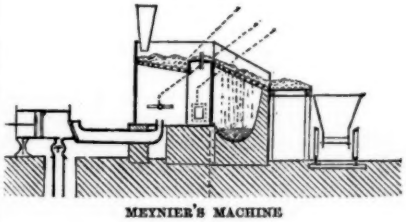
This machine washes 400 to 500 tons of coal per day.

Mr. Evrard has established one of these machines at the collieries of La Charotte; the first cost is £20,000 gold, and the cost of washing 5 cts. per ton of coal.

MEYNIER'S MACHINE.

This machine belongs to the third-class. Mr. Meynier, upon studying the jigging process, considered that the downward or return current of water in the jigging process is prejudicial to the separation of substances in the order of their densities, and submitted to the "jigging" motion a pulsating motion, *i. e.*, an intermittent flow constant in direction, and never returning upon itself. There being no return current, the finer particles of coal are not carried back into the schist. To obtain this pulsating current of water Mr. Meynier obtains, by the action of a forcing pump, which draws the water from a lower reservoir and forces it into a cistern where

FIG. 6.



MEYNIER'S MACHINE

it acts upon the coal through a sieve or perforated plate. The first machine made, in 1852, consisted of a vertical pumping cylinder giving 15 to 18 strokes per min. The washing cistern contained 2 compartments and 2 grates; the denser bodies fell through the upper grate upon the lower one, which was more inclined, and they collected at its foot, where they were emptied at intervals into one of the compartments. This disposition of superposed grates was found to be unnecessary; several other modifications were also made in the disposition of the parts, so that Mr. Meynier's machine, in its simplified and improved form, may be described as follows:

A horizontal pump of 3 to 4 horse-power, with close fitting piston. The water is conducted through a horizontal cast-iron pipe, provided with a valve to regulate the flow, and ending in a long rectangular opening in the bottom of the washing cistern. This form of opening tends to spread out the ascending current

of water. This action is assisted by an oblong plate or valve which can be raised or lowered upon the opening. The flow of water is thus spread out in one of the compartments of a rectangular cast-iron cistern; at the top of this compartment is a perforated sheet of zinc, slightly inclined from the horizontal, upon which is charged the slack coal either direct from the mine or after passing through crushing rollers. A floodgate along the dividing line of the cistern, allows the schists, pyrites, etc., which accumulate along the lower edge of the perforated sheet to be discharged into the second compartment. Over this grate, and over the second compartment, the surface water, charged with washed coal, flows upon an inclined wire grating, where the water drips from the coal into a canal, whilst the coal gradually slides upon a horizontal wickerwork table, at the level of the top of the cars, from which it is loaded into them. There are no buckets and chains to elevate the coal in this machine, but they can be readily adopted if deemed necessary. The use of a bucket elevator would regulate the charging of the coal into the washing cistern, besides economizing labor. The water which finally drips from the coal contains a mixture of mud and very fine coal (called *schlamm* or slime), and is carried to a basin measuring 6.5 by 13 ft., and divided into successive falls.

The operation of coal washing is continuous, as the impurities which accumulate on the perforated sheet of zinc can be carried off at intervals by raising the floodgate without stopping the operation. The schists and pyrites which accumulate at the bottom of both compartments of the washing cistern, are extracted through side doors every day and carried to the refuse heap. The slime or schlamms which are deposited in the large basin are of very different value, according to their purity, which varies with the nature of the coal. When dried they may be sold for domestic use, or used to generate steam. They may be so highly charged with pyrite or schist as to be valueless.

This machine washes 50 tons of coal in 12 hours. According to Mr. Lebleu, the cost of washing with one machine is 7 cents per ton. When two machines are used, washing 100 tons daily, the first cost of each is $2,400, and the cost of washing 100 tons is as follows, in France:

1 machinist at 50 cents per day,..			$0 50
2 laborers...	50	" "	1 00
3 helpers....	40	" "	1 20
Repairs of pump $120, of washer $120,.....			0 80
Superintendence ($200 per annum)			0 66
Sinking fund ($200 per annum)...			0 66
Total, for 100 tons,.....			$4 82

or 5 cents per ton.

RACTMADOUX'S MACHINE

Belongs to the third class. Mr. Ractmadoux obtains the continuous pulsating movement of the water by employing a piston, as in the jigging process, and introducing a supply of water at every upward stroke of the piston, by means of a valve opened. All the water which enters during that time is expelled at the next downward stroke, carrying with it the cleansed coal.

Mr. Ractmadoux also constructs all the parts of the machine of wood with iron straps. This allows defective pieces to be readily removed, and alterations suggested by experience to be easily made. At Montceau-les-Mines, Mr. Audemar has erected a washing apparatus on these principles. At these mines the coal is first sorted into three sizes by passing through shaking tables of perforated sheet iron; the sizes of the holes being respectively $\frac{1}{8}$, $\frac{3}{8}$, $\frac{1}{2}$ of an in.; the surfaces of the tables measure 67 by 32 in. The amount of coal sorted per 10 hours is 150 tons; the Montceau coal gives 20 to 25 per cent. of finest, 30 to 32 per cent. of medium, and 18 to 20 per cent. of coarser slack.

Each of these three sizes is washed in a separate machine; this facilitates greatly the separation of impurities.

The apparatus consists of a water reservoir, two chests divided into three compartments, for the piston, the schists, and the "schlamms." These impurities are withdrawn once or twice a day while the machine is at rest. The coal and water current flows over one edge of the chests on an inclined plane, 6 ft. long, into two additional washing chests, provided each with a piston and inclined sieve. The coal is there cleansed further, and separates itself into a superior quality which flows off the top, and an inferior, taken at the bottom of the layer.

The pistons and chests are of wood.

The pistons are commanded by a belt-gearing and iron connecting rod; at each upstroke of the pistons a valve in the reservoir is opened by a lever and beam, and the water flows from the reservoir under the pistons.

Three of these double pairs of chests are placed side by side, each pair, with accessories, occupying an area of 20 by 14 ft. The area of pistons is 50 by 15 in., the area of sieves is 30 by 50 in.

In 12 hours the amount washed is 300 tons of slack coal, 150 of which are coarse, 90 medium, and 60 fine grain.

The loss from schist averages 4½ per cent., from schlamms, 2½ per cent., from slime carried off by the water, 3 per cent.; together 10 per cent. The consumption of water amounts to 180 cubic ft. per ton of coal.

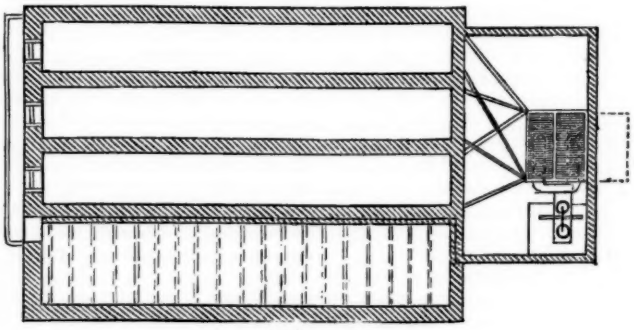
COPPEE'S MACHINE.

This machine, which is essentially derived from Meynier's, belongs also to the third class. It is working at the colliery of Anzin, at La Villette Gas Works, Paris, and at the Mons Colliery, Belgium, with one difference, however—the pump there used is double-acting.

Coppée makes use of two rectangular cisterns instead of one, so that the washing operation is more thorough to begin with. The purification of slaty coal is greatly facilitated thereby, for shale sometimes adheres to the coal, forming particles of intermediate density and light enough to be carried away with the coal; also some slates are formed of unctuous laminæ, which cannot be wetted, and are carried off at first, although heavier than the coal. A fall is given from the first cistern to the second, so that the dry schists are thoroughly wetted and submerged by the fall, and remain on the second perforated sheet.

From the second cistern the current of water and coal flows over a slightly inclined table into one of three basins.

FIG. 7.



COOPEE'S MACHINE.

These basins measure each 65 ft. long, 75 ft. wide, 7 to 7.5 ft. deep, presenting a cubic capacity of 3,530 ft., or one day's stock. They are built of masonry, and the bottom sloped to drain off the water. A vertical sluice at the further end is boarded up gradually as the deposit of washed coal rises in the basin; the excess of water and slime runs over the upper board into a canal to a fourth basin, the bottom of which is inclined against the current in a series of steps. The movement in this last basin is slow, and the black slime or schlamm deposited in this basin is dredged up, allowed to dry, and used for generating steam; at Anzin it is found to contain from 7 to 20 per cent. of ash. These basins assist in classifying the coal, for if kept full of water, the denser and more impure coals will accumulate at the bottom. These can either be washed again or used for purposes requiring less pure coal.

One of the three basins is filled every 24 hours; when full, the flow of water and coal is directed from the cisterns to another basin. The body of coal in the basin begins to dry at the surface, and the boards of the sluice are removed, one by one, from the top downwards, as the

drying progresses. The coal is then charged into cars, and the wet portions are first dried by mechanical means.

When the schists cover the perforated sheets to a considerable depth, the operation is stopped for a moment and the deposits of schist shovelled into a shoot which carries them to a car.

At Anzin the coal from the mine is thrown from the head of the shaft upon a grating, the bars of which are 0.8 in. apart. All the slack which passes through is charged into buckets containing 2,420 lbs.; these buckets are raised by a steam crane and discharged into a hopper placed near the washers. A vertical forcing pump, with hollow plunger, delivers the water to both washing cisterns. The diameter of piston is 26 in.; the piston is hollow, and the connecting rod is attached to a movable crank pin, so that the stroke which is usually 10 in. can be increased to 16. The number of revolutions is usually 20 to 30 per min. The steam cylinder is vertical, of 10 in. diameter and 19 in. stroke; the indicator diagrams for the forward and back stroke are nearly identical. At 20 revolutions per min. the average pressure of steam on the piston is 25 lbs. to the sq. in. corresponding to 4-horse-power.

The pump and washing cisterns are set up under cover in a building; the 4 basins are in the open air.

The labor for washing 100 tons of coal in 12 hrs. consists in 1 machinist who attends to pump and steam crane; 2 men hitch the buckets to the crane and discharge them; they also carry away the schists, etc., to the refuse heap; 3 men attend to the washing proper, and regulate the velocity of flow.

In France the machinery costs $2,400 gold, and the building, basins, and accessories, $5,000 to $6,000 more.

MACKWORTH'S MACHINE

Belongs to the third-class. Mr. Mackworth employs a continuous band elevator to raise the coal from a coal hopper, where it is delivered from the cars to a higher level, where it is discharged in a continuous stream into a vertical revolving hopper through which it descends gradually into the separator; here it meets a slow current of water ascending with a velocity of an inch or two in a second. According to the velocity of this current and the speed of the revolving hopper, the separation of impurities may be graduated to any limit desired.

The separator is a conical vessel 2.5 ft. wide at the top, at the bottom of which enters a current of water driven upward by a horizontal screw agitator. The slow ascending movement of water of about 5 ft. per min. carries upward the clean coal, and a curved arm at the surface drives it upward upon a perforated plate where the water drains off; a brush following the arm helps to keep the holes in the perforated plate open, and drives the coal into a shoot which conducts it to a tram. The bottom of this shoot is a long perforated plate which assists in draining off the water and in drying the coal.

The shale and pyrites fall into a shale box at the bottom of the apparatus, where a bucket elevator dredges them up and delivers them into cars. The water which drips through the finely perforated plates passes back to the agitator and, with the fine silt suspended in it, is driven up again. The same water is thus used over and over again, with some additional water to supply the waste.

The loss of coal in this machine is claimed to be less than 2 per cent. The machine is contained in an area of 9 ft. sq. A driving pulley 2 ft. in diameter making 40 revolutions per min., is placed at the top, 12 ft. above the ground. It is claimed that a force of 1-horse-power will work a machine with pump and elevator capable of washing 50 tons of coal per day. The cost is estimated at 6 cts. a ton in England.

DRYING THE COAL.

After washing, some industries require the coal to be dried before using, as in the production of coal-gas. Any warm area is suitable for the purpose.

Centrifugal hydro-extractors may be used here as in other industries. In Belgium, a centrifugal apparatus is used, consisting of a vertical drum 10 ft. in diameter, within which are 8 baskets fastened at the circumference of a horizontal plate. A velocity of 225 revolutions per minute is given. Each basket holds 88 lbs. Its centre of gravity describes a circle 7.5 ft. in diameter, and its axis becomes alternately horizontal and vertical. From 4 to 5 per cent. of water is left in the coal as a proper amount. Two men can load, dry,

and unload 30 tons of coal in 12 hours. This process is slow and expensive.

A new hydro-extractor, due to Mr. Hanrez, of Belgium, has been tried in Germany. The machine requires no hand labor. The operation is continuous. The wet coal is carried into a feed hopper by a bucket elevator, is delivered into the centrifugal cylinder at the top, and discharged dry into a shoot at the bottom. This machine will dry 100 tons a day.

COMPARISON BETWEEN THE VARIOUS MACHINES.

The step-washing of coal is still used in coal districts possessing an abundant supply of water. The apparatus is simple and the first cost small. This method of cleansing is especially adapted to coal containing laminæ of slate frequently interstratified with it; in the ordinary jigging process, and in the third class of machines, these slates are difficult to eliminate, for they assume a flattened form, and on account of the greater surface they present to the action of water, they are carried upward with the fragments of coal, which are generally cubical in shape, and present less surface for a given weight.

The hand jigging machine, although very effective, requires too much labor to cleanse a small amount of coal.

Bérard's machine presents unnecessary complications. *Revollier's* second machine is an improvement upon it, besides separating the cleansed coal into two qualities. *Edwards and Beacher's* device to impart the jigging motion to the water is simple and ingenious; but whether the oscillations produced are sufficient, and whether the diaphragms are more convenient than pistons, I have been unable to ascertain. Of all the machines of the second class, however, *Evrard's* is the most perfect, for besides subjecting the coal to the jigging process at various depths under water, the rotary motion of the sieve subjects the coal to a lateral or horizontal current of water of 15 or 20 feet per minute, which aids the separation of slate. The first cost of this machine is large, but it cleanses more coal per day, and affords of itself a slime pit without any additional masonry work. Besides, the separation of cleansed coal into three qualities is more easily controlled than in other dispositions. The consumption of water is reduced to a minimum in this machine.

Whenever the jigging process is applied, however, the coal used should not contain much very fine coal, for the downward current of water at each stroke is prejudicial to the finer particles of the best coal. These are repeatedly carried back and mixed with the impurities, and even when deposit basins are used, although this fine coal is finally collected and not wasted, it is nevertheless taken from a superior and transferred to an inferior quality of coal.

The third and fourth classes of machines, where the water does not return upon itself at every stroke, are then particularly adapted to treat coals which produce a great deal of fine coal dust; for this fine and valuable dust is then never entirely separated from the clean coal, and they are mostly deposited and collected together. Coppée's machine is more complete, and an improvement upon Meynier's; it is effective in collecting waste of fine coal and in separating slate.

Ractmadoux's machine is similar to Coppée's, and may be often preferred where wood constructions present advantages. Mackworth's machine is very compact; it does not waste the fine coal, for the same water is constantly used over again; whether the slow continuous current of water of Mackworth's machine is as effective in separating impurities as a pulsatory motion, is doubtful. This machine is also inferior in respect to classifying the cleansed coal into superior and inferior qualities; this, however, is not always required.

There are some points common to all these machines; *i.e.*, the coal has to be delivered from the cars upon a sieve. The use of an elevator formed of an endless chain and buckets, discharging the coal into a hopper, is advantageous; for it allows the supply of coal to be delivered with great regularity, which is essential to the proper working of all these machines. Even where the lay of the ground affords sufficient difference of level to allow the cars to be discharged directly into the hopper which feeds the sieve, it is desirable to regulate by mechanical means the regularity of the supply of coal.

A location upon sloping ground, and a high head of water, are always advantageous; they may allow elevators and pumps to be dispensed with. The intermittent flow can then be obtained directly

from the head of water. An abundant supply of water is of course advantageous; nevertheless, some machines, such as Evrard's, purify coal effectively with a very small consumption of water.

Whether it is best to erect a single large machine or a number of smaller ones, is an open question. One large machine works more economically when in operation; but for convenience of repairs a number of small machines is more convenient, and also safer. The permanence of the operation should also influence the choice. The amount and nature of the impurities, as well as the friable nature and mode of fracture of the coal to be cleansed, are of first importance in the choice of a coal-washing machine. I have known a case where an excellent machine was erected at some cost, and when put in operation proved unsatisfactory. The nature of the coal had not been considered; the coal was slaty, and when crushed broke up in *flat* fragments, while the machine chosen was especially adapted to operate upon *cubical* fragments.

The cost of washing mentioned at different times is the cost in Europe in gold. This affords but little indication of what the cost would be in this country; some elements, however, remain unaltered, such as the labor required, and the production of the various machines.

PERFORATED IRON PLATES.

For trommels, perforated iron plates are now generally used instead of wire screens. They wear better and maintain their form longer. The finer sizes are made of copper and the larger ones of steel; sometimes sheets of zinc are used. The rules sanctioned by practice to be observed in preparing these sheets, are as follows:

1. The thickness of perforated iron plates should always be less than the diameter of the holes punched in them.

2. The space between the holes in the finer plates should not be greater than the diameter of the holes, in the medium plates than half the diameter, and in the coarser plates than one third of the diameter.

When the diameter of the holes is less than $\frac{1}{10}$ of an inch, the size is considered fine; when the diameter is between $\frac{1}{10}$ and $\frac{1}{5}$ of an inch, the size is medium.

COAL-WASHING IN EUROPE.

Machines have been established in Scotland, Cumberland, Derbyshire, Gloucestershire, and Wales, to purify from 20 to 100 tons of coal per day, at a cost not exceeding 6 cents per ton and with a loss not exceeding 2 per cent. of coal.

At the Kirkless Hall Iron Works of the Wigan Coal and Iron Company all the coal dust for the coke required in the blast furnaces is purified from sulphur by washing, and is made suitable for *smelting a high class of hematite iron* for the Bessemer process; the cost does not exceed 4 cents per ton including wear and tear of machinery, steam power, and wages. The waste is about 10 per cent. of impurities and fine coal.

The most important coal district on the continent, is the Valley of the Saar at the frontier of France, Rhenish Prussia, and the Bavarian Rhine province. At the Burbach Iron Works, which are the largest and best arranged of that district, the coal is carefully washed previous to coking; the machinery for carrying out this operation is very complete and effective; the coal is impure and loses 12 per cent. by washing.

At the Kladno Iron Works, Prague, which are the largest in Austria, the fuel used is coke made on the spot from Bohemian coal. The coal of the Kladno mines is very impure and stratified with thin layers of slate, so that *it will not coke at all in its natural state;* it contains a considerable percentage of iron pyrites in crystals of very different sizes, which would render the coke worthless for iron smelting, unless made from picked or purified lots of coal. Yet from these impure coals and from ores containing sulphur and phosphorus, *very good foundry iron and an average quality of forge pigs* are made.

In the centre of France, the St. Etienne district, and in the Northern basin of Anzin, in France, and Mons, in Belgium, coal is washed by hundreds of thousands of tons annually.

The railroad from Kharhof to the Sea of Azof was completed on the 4th inst., thus effecting uninterrupted communication from the Baltic to the Black Sea. The construction of the line, which is upwards of 400 miles long, was only commenced last summer.

NEW GAS-STOVE AT THE ROYAL OBSERVATORY, EDINBURGH; AND THE MANUFACTURE OF WATER.

By C. PIAZZI SMYTH, F. R. S, F. R. A. S., Astronomer-Royal for Scotland, etc.

In a litte garret-room at the Royal Observatory, Edinburgh, there has been introduced a gas-stove, now for nearly a year, with remarkable success after certain principles were efficiently carried out. The proof of success is, 1st, that the temperature of the garret is now from 10 deg. to 15 deg. higher than a similar neighboring garret without a stove. 2d. There is a hot closet, where articles may be maintained night and day at a temperature of about 100 deg. 3d. There is no bad air from the stove, and the garret is indeed sweeter than it used to be before the stove was erected, because the means for conveying away the bad or burned air of the stove are made to remove the bad air from illumination or respiration of any occupants of the garret. 4th. There is no trouble either by day or by night, for the stove is kept constantly burning, and simply produces an accession of heat and comfort to the garret, as if the stove was a natural hot-spring, or "that it went like a clock." 5th. The expense is exceedingly small, on account of the trifling quantity of gas burned; though, that gas being also economically burned to a degree, there was a trouble at first connected with the fountain of water; of which more presently.

METHODS.

1. The supply of gas must be constant; there is, therefore, a regulator of pressure, through which the gas passes before entering the stove, and this completely prevents the flaring up and roaring of the gas-burners, which is experienced in ordinary gas-lights when the pressure is altered on the street gas-main, either by the Gas Company or by the shops turning on or off.

2. The gas is burned in ordinary small "fish-tailed," or "Union," burners, of which there are three, of the smallest size manufactured; and, according to the season, either one, or two, or three are lit. They are preferred to the Bunsen burners, from the cheerful light that they throw out at night through glazed doors in front of the stove; also from burning the gas at least as perfectly, if not more so, from the higher temperature of the bright flame; and also from not being subject to occasional back ignitions, and then smoking, as are the Bunsen burners.

3. The stove is made of sheet iron; it is 32 in. high, 25 in. long, and 18 in. broad at the bottom, but only 4 in. broad at top,—this decrease being produced by the front slanting backwards, as shown in Fig. 1.

5. The heated products of combustion are not allowed to escape upwards to the top of the stove at once, but are made to pass backwards and forwards under 4 successive horizontal diaphragms, before arriving at the chimney, at the upper right hand corner. These diaphragms are fixed in their places by rivets which project outwards an inch. These serve to communicate the heat of the diaphragms to the outside air, as well as to hang things on to be heated or dried; and what with sides and diaphragms of the stove, the heated products of combustion of the gas-lights have to pass over 25 sq. ft. of metal surface before escaping to the chimney. This is an excessively large amount of surface in proportion to the quantity of gas burned, and hence, in a large measure, the economy of the stove.

6. The hot closet is formed by a box or wooden head put over the upper half of the stove, and furnished with drawers and a closet door, as shown in Fig. 2.

The top of the closet and the door are both of plate glass, so that the face of watches, if put inside to be tested for going at high temperatures, may be read as they lie there at these temperatures.

7. To carry away the gaseous products of combustion, there is a chimney formed of a metal pipe 1.5 in. in diameter, which passes through a hole in the ceiling of the garret to the open air outside the roof; the hole being so much larger than the chimney pipe that its annular difference makes a chimney for the bad air of the garret as well.

8. In calm weather, the stove chimney and garret ceiling chimney both act well by the ascensional power of warm air; but in times of wind, the currents are more inclined to blow down than up—the situa-

tion being very exposed, and the winds violent to a degree.

9. To correct these downward currents, therefore, in times of wind (simple cowls having been found inefficacious), there has been established over the top of the two united chimneys a little vertical windmill, working a modification between an Archimedean screw and a fan-wheel, the conical blades of which are always drawing the bad air out of both chimneys, and expelling it to leeward. The action of this apparatus is most admirable, most necessary; for whereas the burning of a single *un*ventilated gas-light in so small a garret makes the air noxious in a quarter of an hour, the ventilated gas-burners keep on burning both by day and by night, and week after week, without any smell or other bad feature being perceptible.

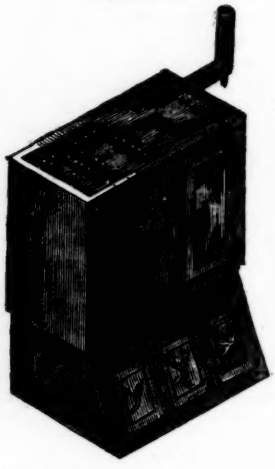
CHIMNEYS IN THEORY AND PRACTICE.

10. A word more on the chimney arrangements of the gas-stove, as applicable to any and all chimneys.

The usual circumstances under which chimneys smoke, or have back draughts, are,—at the chimney-top, where the products of combustion ought to escape, the winds are howling, like ten tigers, and doing

FIG. 1.

FIG. 2.



their utmost to get down the chimney, and so enter the fire-place room, where the fire, by burning and making some upward movement of the air in lulls between gusts of the tempest above, produces a rarefaction.

Architects generally seem to fancy that a principle merely is quite enough for actual practice anywhere; and, therefore, trusting that there is an ascensional tendency in hot air from a fire, though ever so small, inducing it to go up a chimney, they leave that often very weak, almost homœopathic force to contend single-handed against two difficulties—*first*, to wire-draw some air of supply through closed doors and windows; and *second*, to eject the burned air right in the face of the struggling winds and whirlwinds at the top of the chimney-pots. A very little calculation would show that the result must be practical failure, *i. e.*, a smoky chimney, although the ascensional principle of warm air be perfectly true.

No person who lives in a very windy and trying locality can expect to be free from smoky chimneys, unless he corrects both of the evils above mentioned. Let him also, by all means, have as tall a chimney as he can; let him see that the top of it is not dominated by any neighboring mass higher than itself; and let him keep the chimney-stack as warm inside as he can, to promote the ascensional power of warm air; but let him also supply these two things: 1. A pipe to bring fresh air to be burned from the outside, top, and most windy part of the roof; and 2. A *power*-cowl to extract the burned air, and throw it out into the atmosphere,

despite any number of winds howling to get in.

With the Observatory stove, there is an inch-pipe to bring fresh air to be burned in it, not exactly from the outside of the roof, but from a very windy region between the roof and ceiling, which does almost as well. And then for the ejecting of the burned air, there is a little vertical windmill working a diagonal screw fanner as aforesaid.

To those who want a tolerably large measure of efficiency and no trouble in such a *power*-cowl, I would say, get one of James Heworth's patent Archimedean screw ventilators; but to those who have a fancy for realizing the utmost power of the wind according to Smeaton's laws for vertical windmill sails, and do not object to experimenting, I am inclined to say, try the Edinburgh Observatory plan of a vertical sail-wheel kept at right angles to the wind's direction by being at the *leeward* end of the wheel's horizontal axis (instead of the *windward* end, as with ordinary windmills, when they need a special and expensive apparatus to turn their faces always to the wind).

The collar-motion, by which the wheel's face is turned towards the wind, must be rather stiff than free or light; but the motion of the axle of the sail-wheel round itself must be as free and light as possible; and to promote its always turning even in very light airs, the sails, which are plates of tin, are fastened at the most suitable angle for *beginning* to turn, and are fastened by their front edges only; hence, when the wind blows strong, and the wheel is inclined to turn needlessly fast, the tail-ends of the sails are blown or bend more nearly in the direction of the axis of the wheel, and thus slow their motions and decrease the surface on which the wind can act.

MANUFACTURE OF WATER.

11. Let us now suppose that everything has been well-managed thus far with one gas-stove, viz.:

A. Its supply of gas is constant; B. the lights never go out; C. the supply of fresh air to it is always ample, whether doors and windows be open or shut; and D. the extraction of the burned air by the chimney and *power*-cowl is also perfect, no bad smell being ever perceived. Still there is one thing to trouble our comfort—"water, water everywhere," and truly "not a drop to drink." Water issues out of every crack or pore of the chimney, perhaps of the stove also, and it is slobbered about on the roof above out of the cowl's top or out of the sides thereof. Where does all this water come from?

It is the product of combustion; the combination of the hydrogen of the gas with the oxygen of the air; and this is indeed a means of manufacturing water in any place where we can get fuel and air. The Royal Observatory, Edinburgh, on the top of the Calton Hill, is unfortunately far above the level of the water-column of Edinburgh; but its gas-stove up in its topmost perch, just under the roof, is manufacturing water both by night and by day; and enough of that manufactured water is collected now to form a very useful tank of supply—the only supply, if ever the misfortune of a fire should occur.

But why does not water appear similarly, some one may ask, at every fire-place; and why cannot our Southern travellers, dying for thirst in the wilderness, manufacture a supply of water for themselves by merely setting the grass on fire? Merely this one difficulty—the fuel in these cases is not burned *economically*, or according to economy in warming, *i.e.*, the heat is not sufficiently taken out of the burned gases; hence all the water these gases are carrying away is in a state of vapor very highly vaporized, and it refuses to deposit upon anything. But when, as already described in the Observatory gas-stove, the burned air from merely a single gas-burner is made to travel over 25 ft. of conducting metal in the stove, its temperature has been so much lowered that the vapor of water hitherto held in suspension deposits almost immediately it enters the chimney, that chimney being in this case a metal tube, almost like the worm of a still reversed. At first it was a soldered tube made of zinc plate, but that leaked so determinedly, and disastrously too, at all sorts of places, that it had to be substituted by a stout leaden pipe; and this again, to prevent the chimney water running back into the stove, had to be made with a bend-down, before entering, or rather after leaving, the stove, as may be seen in Figs. 1 and 2, that bend being further provided with a stop-cock or place of escape for the water that runs down to it.

At that point there is now a glass jar always placed to catch the water as it falls out; and an exquisite sight it is when full, the water being colorless, clear to admiration, and refractive nearly as crystal —this latter quality arising from the salts held in solution, and which are probably enough, after all, to prevent drinking water being ever manufactured in this way, so long at least as it can be procured in any other, and men are not absolutely dying of thirst.

As to the quantity of water that is produced in this manner, I can only speak as to what forms in the *vertical* part of the chimney-pipe, for a long horizontal portion of the same beyond ejects its formation upon the open roof, and, evaporating there, makes a white, chalky-looking mess. But in the grass plot, under the vertical portion, there are caught in 24 hours, when all 3 burners are alight (consuming apparently a little under 120 cubic ft. of gas in that time) 50.6 cubic in. of water.

DETERMINATION OF THE SATURATION POINT OF STEAM.

By G. A. HIRN.

Translated from "Der Civil Ingenieur."

It is a fundamental law of thermodynamics, that the quantity of heat given off by a body during its return to its original condition, is equal to the mechanical work which it has developed. If this work is zero, the amount of heat remains constant.

Suppose that steam of tension P_0, and density V_0 is generated in a boiler, and that it passes without change of tension through a vessel in which its temperature changes from T_0 to P_1, and its density from V_0 to V_1. As it enters a vessel containing gas of tension P_1, it expands suddenly, and its density and temperature are converted into V_2 and T_2. As the wall of this vessel is of the temperature $T_3 < T_2 < T_1 < T_0$ it is condensed and returns to its original condition. These processes are complicated, but the final calorimetric result is simple. The heat expends on the water in the boiler an external work equal to $P_0\ V_0$, and an internal work L_0, which separates the molecules. In the superheating apparatus there is exerted an external work $P_0\ (V_1 - V_0)$ and an internal work L_1; both corresponding to a quantity of heat Q. If the steam enters a condenser, the molecules acquire a very great velocity (about 800 metres), which is lost in eddies, shock, and friction; and the consequence of the condensation of the steam under the pressure P_1 is external work, $P_1\ (V_1 - W_0)$, and internal work, L_2, corresponding to the compression of the molecules.

All this work in boiler, superheater and condenser, expresses itself in the bubbling noise of the boiling water, and the hissing of the issuing steam; and its dynamic value may be neglected. It is partly negative, partly positive, and the resultant is zero.

In whatever way saturated or superheated steam is condensed, whether by sudden expansion from P_0 to P_1 (say 5 atmos. to 1 atmos.), or by injection of cold water; the quantity of heat must be at least the same as at first.

If t_0 is the temperature of the steam,
M the weight of a given volume,
m the weight of the injected water,
then in order to produce a mixture of water and steam from water of the original temperature 0°, under a pressure P_0 corresponding to a temperature t_0, there must be employed a quantity of heat

$$Q = M(606.5 + 0.305t_0) + m\ C\ t_0;$$

C being the specific heat of the water. According to Regnault

$$m\ C\ t_0 = m\ (t_0 + 0.00002\ t_0^2 + 0.000000\ t_0^3)$$

This quantity Q must be found again in the condensation, if the steam has no external work to do; a condition easy to realize, if the steam issues directly into cold water, thus preventing the rushing noise which indicates the performance of external work.

Let N = the weight of the cold water,
t_0 = the final temperature,
t_1 = the initial temperature;
then m can be determined from the equation—

$$M\ (606.5 + 0.305\ t_0 - t_2) + m\ C\ t_0 = N\ C^1\ (t_2 - t_1)$$

The exactness of the value of m depends on the exactness—

1. Of observations of the temperature t_0, t_1, t_2.

2. Of the weight N (especially of $N+m+M$).

3. On the prevention of loss or gain of heat.

The mercury-gauge gives the pressure P_0 exactly, and t_0 can be found from Regnault's tables; t_1, and t_2 can be observed to within $\frac{1}{100}$ by means of a thermometer divided decimally read with a microscope. If $t_2 - t_1$ is not greater than 20 deg., the temperature of N can be determined to within $\frac{1}{1000}$. If with reference to the external temperature t,

$$t - t_1 = t_2 - t,$$

and N is very large, the errors resulting from the external cooling or heating of the condenser are practically eliminated. By means of Kappelin's hydrostatic press $N+M+m$ can be weighed to within 0.0001 kil., for a gross weight of 30 kil.; giving a sufficiently accurate value of $M+m$. The rushing of the steam due to the condensation and the consequent loss of work can be prevented in a great measure by conducting the steam into the cylinder by means of a long bent tube with a narrow opening. The steam is partly condensed in the tube under the pressure P_0; so much so that hardly any sound is heard during its passage.

Another method is of more limited application, but leads to more accurate results; it is more limited, since it is suited only to the generators of steam-engines; more accurate, because it specifies the amount of water of condensation used during an entire day.

Suppose the whole quantity of water and steam which the boiler of a condensing steam-engine gives off to be determined; and that

W = the quantity,

m = the unknown quantity of spray water,

t_0 = the mean temperature of the mixture,

t_1 = the mean temperature of the water of condensation; then the quantity of heat expended by the boiler is given by the formula

$$Q_0 = (W-m)(606.5+0.305\,t_0-t_1) + m\,c_1\,(t_0-t_1).$$

Again if

N = the weight of the condensing water,

t_2 = the temperature of the water injected, the quantity of heat which this water takes up is

$$Q_1 = (N-W)\,(t_1-t_2)\,C.$$

But in this case Q_1 is not equal to Q_0, if the external work is not considered.

If F is the effective work of the steam, as shown by Watt's indicator, we have, from a fundamental principle of the theory of heat,

$$425\,(Q_0 - Q_1) = F$$

and hence

$$(W-m)\,(606.5+0.305\,t_0-t_1) + m\,c_1\,(t_0-t_1 = (N-W)\,(t_1-t_2)\,C + \frac{F}{425},$$

which gives

$$M = \frac{(N-W)(t_1-t_2)C + F \div 425 - W(606.5+0.305t_0-t_1)}{C_1(t_0-t_1) - (606.5+0.305\,t_0-t_1)}$$

As t_1 seldom amounts to 40 deg., we can, without great error, put $C = 1$. According to Regnault's formula

$$q = \int_{t_0}^{t_1} C^1 dt = t_0 + 0.0000\,t_0^2 + 0.000000.3\,t_0^3$$

and with close approximation

$$C^1\,(t_0-t_1) = t_0 - t_1 + 0.00002\,t_0^2 + 0.0000003\,t_0^3.$$

The exactness of the value of M so calculated, depends on the accuracy of the values of W, N, and F.

This method serves to test an engine, by determining its efficiency, and detecting its faults. Suppose 5 of the qualities W, m, N, N−W, and F, to be known; then the sixth can be determined. We cannot too strongly recommend to engineers that they make experiments in this direction wherever opportunity occurs.

In England a patent apparatus is used, which is applied to the orifice of the condenser, and registers the volume and temperature of the water discharged; that is, it continually records values of N and t_1 coarsely approximate.

With reference to the determination of the weight of water and steam, W, furnished by a boiler in a given time, but little can be said. At present we have no direct means of determining the quantity with accuracy; still the measurement of the amount of supply is a simple and easy method of obtaining the desired result. Several kinds of registering apparatus have been invented, no one of which is certain in its indications.

Still more difficult is the exact determination of the amount of water, N, discharged from the condenser. In large engines

this amounts to 6, 7, and 8 kilos. in a second, or 4 to 5 cubic metres in 10 minutes. It is not easy to gauge with accuracy such quantities. The best method is by division into small quantities and summation. The water lifted by the condenser is discharged into a long box 1 @ 1.2 m. high, 0.4 @ 0.5 m. broad, and 1 @ 1.2 m. long. In the bottom of this box is fixed a long strip of brass or lead, pierced with round holes as nearly equal in area as possible, having a diameter of 15 @ 20 millim. The orifices should be from 15 to 20 millim. apart. The discharge from an orifice of 20 millim. diameter under a head of one metre is 0.8 kilog. per second. So that six or seven are necessary to discharge 5 @ 5.5 kilog. in a second. The discharge of each orifice should be measured by the water-inch. This is accomplished by stopping the orifices with corks, filling the reservoir with water of a temperature equal to that of the water of condensation, and then uncorking the orifice whose discharge is to be determined, and counting the number of seconds required for the surface to sink from 0.4 to 0.5 metre. If

S = the transverse section of the vessel.

H_0 = height of water at first observation.

H_0 = height of water at final observation.

T = interval of time.

Then

$$\frac{2\epsilon}{T\sqrt{2g}}(\sqrt{H_0}-\sqrt{H_1})=(\mu S)$$

and the quantity ef discharge under the constant head of H is

$$V=\mu S\sqrt{2gH}.$$

The area of the transverse section of the vessel is most accurately determined by weighing the quantity of water required to raise the surface from H_0 to H_1. The total discharge is of course the sum of all the partial discharges determined by the process described. Suppose that the sectional area of the vessel is $1.2 \times 0.5 = 0.6$ sq. met., and the surface of the water falls from 1.2 to 0.8 met.; then

$$T\mu S=\frac{2\times 0.6}{\sqrt{19.6176}}(\sqrt{1.2}-\sqrt{0.8})=0.05446195-T.$$

For the openings of 2 centim. diameter we have approximately

$$\mu S=0.6\times 00031416=0.000188496;$$

hence

$$T=\frac{0.05446195}{0.000188496}=288.9 \text{ seconds.}$$

The time can be observed to within $\frac{1}{2}$ a second, so that the value of μ S can be obtained to within $\frac{1}{3}\frac{1}{8}\frac{1}{0}$. The height $H_0 - H_1$, when about 0.4 metre, can be found within $\frac{1}{2}$ millim., or within $\frac{1}{8}\frac{1}{0}$. Consequently the value of N can be found with great accuracy from the equation

$$\frac{1}{\gamma}N=\mu S\sqrt{2gH}$$

in which γ is the density of the water and H the mean head.

The quantity of water, N, discharged from the condenser into the measuring vessel is found by observing the head, H, for every minute during half an hour's time, and taking the means of the values given by the formula

$$N=\gamma\mu S\sqrt{2gH}.$$

The accuracy of the value thus obtained depends upon the exactness of μ S, and thus in turn upon the exactness of the measurement of the section S.

The quantity, m, is found by comparison of N with the quantity W found by direct measurement. Let us suppose $\mu = 0$, which happens (1) when work is done by superheated steam, or (2) when the cylinder is well packed.

In the first case

$$W=\frac{N(t_1-t_2)+F\div 425-}{606.5+0.305\,t_0+0.48(T+t_0)-t_1+C(t_1-t_2)}$$

in which T is the temperature of the superheated steam.

Very complex relations occur in the case of cylinders with steam jackets, to which we will briefly refer. A portion of the steam condenses in the jacket, on account of the external cooling; another portion condenses because of the loss of heat by the expansion and cooling of the steam in the cylinder.

The advantage of Watt's steam jacket consists in this interchange of heat and effects a saving of 20 per cent., according to my own experiments as well as those of Combes.

Again, a portion or all of the spray-water is precipitated into the steam jacket. I have assumed that all the water is precipitated; but, as remarked by M. Leloutre, it does not matter whether all or but a part reaches the cylinder, for this

water would be converted into steam by the heat imparted to the cylinder, and a volume of steam corresponding to the spray-water would be condensed in the jacket. In all well-constructed engines the cylinder is placed over the water surface of the boilers, so that the condensed water can run back, or, where this is not practicable, the water is allowed to escape from the jacket.

In these cases $\mu = 0$, and we have

$$W = \frac{N(t_1 - t_2)C + F \div 425}{606.5 + 0.305\,t_0 - t_0 + C(t_1 - t_2)}.$$

Hence, if N, t_1, t_2, T and F, are known (by the indicator), the steam required at any moment can be determined; hence the advantage of this method. For example, if W is determined from the amount of supply, one must observe at least 12 hours to obtain a trustworthy result; but with this method it is only necessary that the engine work 30 minutes in order to determine the amount of steam consumed, so that many trials can be made in one day, under varying relations of tension and expansion.

The total work of the steam in the cylinder can be found within $\frac{1}{500}$th by Richards indicator; or it can be calculated from the equation above after measurement of W. The quantity of heat $\frac{F}{425}$, and consequently F, is obtained from the difference, $Q_1 - Q$, of two large numbers which depend upon very many elements difficult to determine. Small errors which enter into the experimental factors of Q and Q_1, introduce great errors in the value of F. In my earlier experiments to determine the mechanical equivalent of heat, I employed this method, and the results have been proven incorrect.

Finally, we now have in industrial physics two exact methods for measuring the quantity of spray-water from the boiler, and one of these methods, besides giving the special results referred to on this article, is sufficient for the most complete investigation of the steam-engine.

IRON SHIPS AND IRON-SHIPBUILDING.

From "Appleton's Journal."

There is now living in England, at a not extreme old age, a ship-builder, who declared that the building of ships with iron was against Nature, and that he, for one, never would use that material. Whether he has used it, we are not informed; still, he has lived to see the use of wood as rare in that country in that business, as was iron when he made that assertion. Like all new inventions which are radical improvements, the use of iron for ships' bottoms met with much opposition, was slow to come into use, and the details of its manufacture imperfect. Still, when we look at the fact that it was introduced in England; of the immense prejudices to be overcome; that it had, in a measure, to be forced upon an Admiralty and Board of Underwriters, and a people wedded to old ideas; that its use came in direct opposition to, and threw out of employment, a wealthy class of builders of wooden ships and their numerous workmen, and made necessary a new knowledge of construction in naval architecture, thus having arrayed against it all the prejudices of ignorance and interest, we cannot but wonder that the introduction has been so rapid. We may almost say that, viewing all these things, the progress of the use of iron for the building of ships has been without a parallel in the history of inventions.

We can well imagine the incredulous sneers with which the old style shipwrights spoke of the possibility of making iron float, and what faint hopes the friends of the seamen who first took voyage in an iron ship had of ever seeing them again. And still, with what exultation the same shipbuilders hailed the news that one iron ship had parted her seams in a gale and foundered at sea, and another, beached on the shore, had "hogged" and broken amidships! But the shrewd moneyed men soon found that the iron ships brought more cargo, and their average loss by shipwreck or otherwise was not even so great as the wooden vessels, while on the score of economy in construction they had greatly the advantage. Science, as it progressed, has made them still more safe by the introduction of bulkheads—at least an apparently new idea, certainly one never thought of in England, though familiar

enough to that strange people who are behind us, yet ahead of us, who know so much and yet so little—the Chinese—who had, perhaps, for untold ages, used a similar construction in their vessels; they being divided into many compartments, all water-tight, wherein was stowed each trader's cargo separate. The introduction of the bulkhead system of construction marks an era in iron ship-building, and a vast step toward the perfection of safety in travelling by water. Numerous instances are quoted of vessels sailing hundreds of miles with one compartment filled with water, some with two, and we have ourself seen an English steamer land her passengers and two-thirds of her cargo in New York perfectly safe and dry, when she had a hole in her bow through which one might have easily driven a horse and cart.

The great difficulty in the early history of iron ship-building was to get a rating at Lloyds'. That conservative establishment, acting upon the motto, "Prove all things; hold fast to that which is good," and, we might add, not be very anxious to take hold of any thing better, waited with great patience, and still with greater incredulity, the result of the experiment of the first iron vessels. Even when their good qualities were proved, they gave way reluctantly, and their rating is yet more on matter than manner, quantity than quality. Defective, however, as it may be, we must make allowance for the fossilized ideas of some of our English brethren, especially when we reflect how that sleepy old Board must have been taken aback by the innovation.

Lloyds' register has existed about one hundred and ten years, having been commenced in 1760. It was a crude affair at first, but about 1810 became a permanent and recognized institution, with a fixed set of rules for rating and building. It is natural that they should have some pride of antiquity about them, and equally natural that some prejudices as to shapes and materials of vessels should enter into their regulations. It has now on its register over 13,000 vessels, representing over 6,000,000 tons carrying capacity, and valued at over $700,000,000 gold. It pays out in salaries over $100,000 gold annually, and endeavors to employ the best talent for its uses. Their rating for iron vessels is, in brief: The iron must be capable of standing 20 tons' longitudinal strain per sq. in. For vessels of 2,000 tons and over, the iron must range from 11-16 to 15-16 in.; for 1,000 to 2,000, from 9-16 to 13-16 in.; from 500 to 1,000, 7-16 to 11-16 in. in thickness. Then there are specifications as to shape, rake, etc., position of iron of different thickness, interesting to no one but the practical shipbuilder. Their highest rating is for 12 years.

This establishment has slowly been made to acknowledge that 10-16 of an inch of iron is as strong as 6 in. of their boasted oak, even when the iron was dug from and manufactured on their own soil, and they must have as long a time to learn that an American iron of 8-16 is at least of equal strength, and entitled to the same rating as the English 9-16ths. This question of allowing a different thickness on account of greater strength, is of immense importance to Americans, as ships built of our iron, equally as strong or stronger than the English, might be made of plates at least 1-16 less in thickness; hence would be that much lighter, and carry equivalently as much more cargo. But the influence of the English Lloyds extends over the whole world; thus even our own insurance companies follow their behests, and any ship-owner who dares transgress their rules would find his ship rated down here as well as abroad, and his insurance rates raised, notwithstanding he might build her of iron standing a strain of 75,000 lbs. to the sq. in. This state of affairs is not so especially applicable to vessels in our coasting trade.

The first iron vessels of which we have any definite record, were employed as canal boats in 1812, though it has been asserted that a boat, constructed of iron, was used on the Severn in 1789. In 1822 a vessel was built of iron, and run from London to Brest, navigated by Admiral Napier. In 1830, iron ships were introduced on nearly all the English canals, with paddle-wheels recessed in the stern; but the first to take a long sea-voyage was built at Liverpool, by Jackson & Gordon, for Cairns & Co., and launched October 17, 1838. She was named "The Ironsides," and measured 271 tons burden. She sailed to Rio de Janeiro and returned safely, with cargo dry. This experiment was soon followed by others. Until 1844, the only rating given them by Lloyds was,

"built of iron;" from that date to 1854 they were rated "A 1 for six years, built of iron;" in that year rules were adopted, which exist, as then, with some few alterations. We have above stated the principal points of these rules.

Among the first and most persevering builders of iron ships was Fairbairn; and his successors, the Lairds, still continue the business. He states that he built one hundred iron vessels, most of them at a loss, and saw them all successfully sailing on the ocean, before the Lloyds and Admiralty were willing to admit the success of iron as a material for shipbuilding.

The first ships were built by bringing both edges of the iron flush to each other, strengthened by a narrow plate inside the seam. This was soon abandoned for a system of lapping one edge of the plate over the next under, as in ordinary weather-boarding or slate-roofing. This is used by some yet, but has been almost entirely superseded for a system of alternate lapping, every other plate resting over, the edges of its neighbor. Some have gone back to the original idea, because of the smooth bottom it makes; but it is the almost unanimous opinion of ship-builders that strength is thus sacrificed to beauty and increased cost. Framing is used as in wooden ships—some using transverse and some longitudinal framing, most a combination of both. The ribs rise in one solid piece, from keel to deck-sides, are usually inverted ⌊ shape, or square ⊏ placed sideways, or thus ⊐, sometimes an L. These shapes are preferred.

The theory of iron ship-building is in brief this: A stick of timber, of a given size and length, weighing just a ton, will displace so much water and float; make a water-tight box of iron, the same size of the timber, so constructed as to also weigh just a ton, and it will also float, and displace the same quantity of water. Hence, it will carry just as much weight as the timber; then make your box the same size, but weighing only half a ton, and you find that it will sustain the other half ton weight in cargo. Therefore, as iron is ten times stronger than oak, or other ship-timber, it may be made ten times thinner, relatively lighter, and more buoyant. This simple experiment is the basis of iron ship-building, and, in itself, overcomes all the ignorance and the prejudice against the use of that metal. The only question was to determine shapes, and machines to work into the requisite shapes.

Mr. Scott Russell says, to make a good iron ship-builder, a man should be a good mathematician, a mechanic, and at least a theoretical naval architect; next, he should be a mechanical engineer, thoroughly understanding the different grades, qualities, and characteristics of iron, and also should have gone through with and understand practically every detail of the business. As a large part of the work in iron ship-building belongs to the machinist's and blacksmith's trade, the construction of such vessels was taken up by the same persons who built the machinery for steamers—the engine and machine ship-owners; and such must be the case here for successful and economical work.

Steel has also been used in England as a material for boat-building; and, where extremely light draught is required, has very decided advantages over iron, though much more expensive. The Lloyds reduce the thickness one-quarter of an inch for vessels built of steel. Another style of boat, lately introduced, but not likely to become very general, is called the composite, being composed of iron framing and wood planking. The only advantage claimed for it is, that the bottom may be coppered, but even then that metal has been found to act on the iron ribs and bolts.

Tonnage is not what weight a ship can carry, but, by English law, is the space she has, counting 100 cubic feet to a ton. Builders' tonnage is to multiply the length and breadth, then this by one-half the breadth, and divide this product by 94. The cost of building iron vessels in England is from £18 to £30 per ton, with an additional cost for steamers of £45 to £55 per horse-power. The materials there are considered to be about three times the cost of the labor. Mr. Scott Russell thinks a vessel should have one ton of tonnage for every mile of the journey she is to perform. His very perfectly proportioned steamer, the Great Eastern, of 18,915 tons, might have gone down to futurity as a magnificent failure, but for the grand work in which she is now engaged. Mr. Russell thinks, too, that a ship should have as many as seven breadths in her length. There is no doubt but local causes, and the character of freight to be carried,

must influence these proportions. Where speed is a desideratum, as in a passenger steamer, a narrow, long, shallow steamer is undoubtedly best.

In France it is stated that the cost of building is about the same as in England. As to the profits, it is stated that one company on the Tyne cleared 30 per cent. on its capital, in 1867, and declared a dividend of 12½ per cent. On the Clyde, the business is increasing, as also the number of firms. That river is now the chief seat of iron ship-building, and we append a statement of the work done there:

	Vessels of all kinds.	Tonnage
In 1863.....	170	124,000
" 1864.....	220	184,000
" 1865.....	267	158,300
" 1866.....	247	129,989
" 1867.....	241	114.593
Orders, end of 1867.....	130	115,124

Of those in 1867, only 32 were wood and composite.

On the Mersey, in 1867, there were 44 iron vessels built, tonnage 40,564, and 10 on the stocks; also 35 large iron barges built and 4 small composite vessels. On the Tyne, in 1867, there were 81 iron vessels built; tonnage 31,075. We have no exact statement of later date but the broad one that there was no decrease during 1868, and that the trade is still brisk, as of late years.

In the United States, the first iron boat was, we believe, built at Boston, to run from that port to Portland. So far, but two sailing vessels of iron have been built: one in Boston, the other at Wilmington, Delaware. At the latter place, and Chester, Pennsylvania, have been built nearly all the iron boats of this country—most of them river steamboats and coasting steamers. The largest and only ocean steamers built were constructed at the Novelty Works, in New York city. The business is rapidly growing in this country, as the number of vessels on the stocks and contracted for at Wilmington and Chester will attest. It is probable that, in those places, iron vessels can be built cheaper than in New York or Boston; that the Delaware and the Alleghany may be to this country what the Mersey and the Clyde are to England. We say the Alleghany, because we think that in time the wooden hull of our Mississippi palaces will be supplanted by the lighter and stronger iron. In a close calculation of cost, the saving in transportation of coal and iron must tell; and, too, there is, no doubt, much greater ease in controlling labor there than in the immediate limits of a large city. As the ship-building trade has left London, and is gradually concentrating around the great coal and iron centres—the Tyne, the Mersey, and the Clyde—the last having an acknowledged advantage over the others—so we may assume that the future ship-building of this country will be carried on nearest to its great coal and iron centre.

As to quality, no better ships than those built at Wilmington and Chester have ever floated in English waters—but few as good; and, as respects models for economy of fuel and great carrying-room, none ever were built by any nation superior to those of a line which takes a weekly departure from an East river pier to a Southern port. During the war, monitors and iron-clads were built at various places, but, as these boats were all heavy wooden frames, iron-plated a few feet only, they hardly belong to the legitimate class of iron-built vessels.

We are assured that iron vessels can be built on the Delaware for about 5 per cent. more than in England—that such is the contract price for a number now on the stocks; while, could we get credit for the greater strength of our iron, they would rank one-third higher than English built.

The advantages of iron vessels are their strength, buoyancy, greater tonnage to given draught of water, and easier storage of cargo. The great disadvantage is, the action of salt water on the bottom—no paint or covering having yet been found which, at the same time, protects the iron from rust, and prevents the incrustation of barnacles and growth of grass. A list of the numerous compounds which have been patented for this purpose, and found almost utterly useless, would fill pages. But, even with this very great obstacle, the use of iron for the building of ships is every day increasing, even to such an extent that we may see in our port vessels whose cabin only is of wood—masts, spars, and rigging, all iron—and some with the decking also of that material. The advantage of these latter uses of the universal metal is not yet so evident, nor likely to become, for some time, so general as its use for the construction of the hulls. One of the ablest and most efficient con-

structors in our navy but a few days since remarked to us: "We have never yet built an iron vessel in any of our yards, and some have their doubts as to them; but, sir, we have got to come to it, we have got to come to it."

EXTRACTS FROM FIRST ANNUAL REPORT OF MASSACHUSETTS RAILWAY COMMISSIONERS, JAN., 1870.

THE EXTERNAL RAILROAD SYSTEM.

Hitherto, among us, public attention and the discusion of the press have been almost exclusively devoted to the condition of the external relations. The great Northern lines, the Hoosac Tunnel, the Boston and Albany and the Boston, Hartford and Erie roads have absorbed the public consideration to the exclusion of the internal system. If, however, the future of Massachusetts is bound up in the development of her manufacturing interests, such a method of observing the working of her railroads is very incomplete. The business of the through lines is, promptly and cheaply to keep up communication between ourselves and our producers and customers. Our railroads must perform on the one side what the sea does on the other, and it is perfectly immaterial to more than nine-tenths of the industry of Massachusetts, provided only it is done cheaply and certainly, whether raw material, food, power and manufactures come and go to and from the State by way of Ogdensburg or Baltimore, Albany, New York, or Portland. The Commissioners are satisfied that what has been done in the past in this respect as to supplying channels of communication for this purpose, leaves nothing to be desired. Five through lines now do or soon will connect Massachusetts with the West, and the perfect development of some single one of these lines is the first and absolute preliminary to a successful system of cheap transportation. Massachusetts has committed herself beyond recall to a policy of competition in this business. It is useless now to discuss, whether, for the necessities of her development, the wiser policy might not have been found to exist in the course pursued in Maryland and Pennsylvania,—in the thorough develop- of a single line, or of two single lines to different points, one being Albany and the other Ogdensburg. It is sufficient to say that this policy was not adopted, and that the contracts now in force in relation to tunnelling the Hoosac Mountain, and the aid already granted to the Boston, Hartford and Erie road, have placed the completion of those enterprises beyond the pale of controversy. It does not admit of doubt that if any one of the lines connecting Boston with the Hudson is ever developed to its full transporting capacity, it alone will suffice for the probable future wants of the people of Massachusetts; should the four lines between the same point and the Hudson or the lakes ever be developed, even to the present incomplete degree of the Pennsylvania Central, a population and foreign commerce could be sustained in Massachuetts and Boston more dense and larger than that of Liverpool and Belgium combined. If, however, the mission of the roads is primarily to supply the wants of a densely populated manufacturing community, and only secondarily to act as channels of foreign commerce, it is scarcely probable that they should ever be taxed to their full capacity. This is unfortunate, as it is a well established principle that the more roads have to do the cheaper they can afford to do it; and the converse proposition is no less true, that where the volume of business is limited, the more roads it has to sustain, beyond a certain limit, the heavier tax it has in the long run to pay to sustain them.

FARES ON THROUGH TRAVEL.

The accompanying table sufficiently exhibits the fares exacted on this branch of transportation in this country as compared with those on similar lines in different countries of Europe.

In examining this table, it must be borne in mind that the European rates of speed only apply to first class travel,—that of express trains;—the second and third classes travel at a rate much less than that indicated. The introduction of what are known as "drawing-room" or "palace" cars, supplies, as regards the American roads, in the table, the place of the European "first class;" and the ordinary

RAILWAY LINES.	Distance, in Miles.	Speed: Miles per hour.	FARES. First Class European and American Drawing-room Car. Gold.	FARES. First Class European and American Drawing-room Car. Currency: Gold at $1.25.	FARES. First Class European: First Class American. Gold.	FARES. First Class European: First Class American. Currency: Gold at $1.25.	FARES. Third Class European: Second Class, or Emigrant American. Gold.	FARES. Third Class European: Second Class, or Emigrant American. Currency: Gold at $1 25.	RATE PER MILE, IN CENTS. First Class European: American Drawing-room Car. Gold.	RATE PER MILE, IN CENTS. First Class European: American Drawing-room Car. Currency: Gold at $1.25.	RATE PER MILE, IN CENTS. Second Class European: First Class American. Gold.	RATE PER MILE, IN CENTS. Second Class European: First Class American. Currency: Gold at $1.25.	RATE PER MILE, IN CENTS. Third Class European: American Emigrant. Gold.	RATE PER MILE, IN CENTS. Third Class European: American Emigrant. Currency: Gold at $1.25.
London to Edinburgh	400	38	$16 80	$21 00	$12 24	$15 32	$7 92	$9 90	4.20	5.25	3.06	3.83	2	2 50
London to Liverpool	201	37	8 40	10 50	6 24	7 80	3 84	4 80	4.18	5.25	3.10	3.88	1.90	2.38
Paris to Marseilles	537	28	18 38	22 97	15 78	19 72	10 05	12 56	3.42	4.28	3	3.69	1.89	2.38
Paris to Brussels	228	35	7 14	8 92	5 36	6 70	3 70	4 65	3.13	3.90	2.33	2.90	1.60	2.04
Boston to Chicago	1,038	27	25 20	31 50	20 80	26 00	10 80	13 50	2.45	3.06	2	2.50	1.04	1.30
Boston to New York	238	27	6 00	7 50	4 80	6 00	3 20	4 00	2.52	3.15	2	2.52	1.36	1.70

car, with which alone most of our roads are equipped, is entered on the table on the same footing as the European "second class," though it is infinitely superior in all respects. The cars entered as "third class" in the two countries are equally convenient. From this table it will be seen that the ordinary first class American travel between Boston and Chicago, or New York, is accommodated at the price established in England by law for the advantage of the poor classes, and that the American "palace car"—the most luxurious form of conveyance known in the world—costs the same in currency that the second class car in England does in gold. In every grade the advantage is strikingly in favor of the American traveller, both as regards comfort and expense. Whatever the future may bring forth, it is safe to say that nowhere in the world is the transportation of persons now so cheap as on some of the American through lines.

THE CARRIAGE OF FOOD, COAL AND RAW MATERIALS.

The great needs of this community in its present industrial phase, as has been already pointed out, are power, food and raw material; if these are adequately and cheaply supplied there need be no apprehensions of a declining prosperity. The interests of this community and of its railroad corporations, in regard to the transportation of articles coming under these heads—almost all of which come from beyond our limits as a State—would, if correctly understood, be found to be identical. The permanent value of our railroads to their stockholders depends wholly on the prosperity of the districts through which they run, and the prosperity of those districts directly depends, with us, on the command they have over raw material to feed and power to work their machinery, and food to sustain their population. These, constituting bulky freights, the roads should, with a view to their own interests, seek to supply at the lowest possible paying rates, and to draw their larger profits from the resulting prosperity. This cardinal point of policy they do not now seem fully to appreciate. Take for instance the case of Worcester. This city now contains 40,000 inhabitants, engaged in very diversified descriptions of manu-

facturing industries, all branches of which are dependent on power for the operation of their machinery. There is no reliable water power to be had, and the city is, therefore, forced to rely on coal from the Cumberland region, and from Pennsylvania, or from the Provinces. Every pound of this is brought to it by rail, and over 100,000 tons are consumed per annum. During the last year this amount was brought to Worcester in the manner and at the cost for transportation set forth in the subjoined table.

The Commissioners wish to call particular attention to the conclusions to be deducted from this table. The whole of the sum of money charged for this transportation is a tax on power, and a drawback on the prosperity of Worcester. Were the coal mined in the immediate vicinity of that city, and the transportation tax done away with, both Worcester and the railroads would be immeasurably more prosperous than they now are. As it is, the transportation tax is, to a great degree, a necessary and an inevitable one, and it only remains to divide it into its component parts of cost of transportation and profit, the profit representing the tax imposed for the benefit of the railroads.

There is no article of freight which admits of such cheap carriage as coal in bulk. In England, the rates upon it, as upon all other articles, are fixed by Act of Parliament, but they vary as regards the several companies. Two cents per ton per mile, for a less distance than fifty miles, is the usual rate, which does not include terminal handling. Very large profits are made by the companies transporting coal under this limitation. In two cases, at least, the cost of transportation has been analyzed with almost exactly the same result; the Eastern counties road claiming a profit of two-thirds while transporting at 10 mills per ton per mile, and the Great Northern a profit of thirty-three per cent. while charging 7 mills per ton per mile. The average English charge is 15 mills per ton per mile, which includes everything but terminal handling. On the nine principal French lines, for distances not exceeding fifty miles, the average charge is about fifteen per cent. less, or 12 mills per ton per mile. From a special report on coal, made by S. H. Sweet, Deputy Engineer, to the Legislature of New York, in 1866, it appears that the cost of transportation of this article on the roads of New York and of Pennsylvania, varied from 3.10 to 18 mills per ton per mile; the average cost on twenty roads in 1863 being 9.28 mills. This may therefore be taken as representing the cost of American roads in general. Those specified were mainly roads doing a large business in transporting coal; but it is to be remembered that the cost of carriage does not depend so much on the amount transported, as on the steadiness of the demand and the proportion preserved between it and the rolling stock employed. Wheels kept continually in motion earn a profit out of very low rates, even on a limited business.

The distance to Worcester from tide-water is not over forty-four miles, but the roads leading to that city run through a region crowded with manufactures; the demand is steady and the business of transporting coal might be largely increased. The Commissioners are inclined to think that the present cost of coal carriage on these lines does not exceed, even if it equals, 14 mills per ton per mile, not including charges for terminal handling. 15 cents per ton at each end for these charges, the cost per ton from Boston or

RAILROADS.	Where from.	Number of Tons.	Distance in miles.	Over 5,000 tons to one person. Cost per ton.	Over 500 and less than 5,000 tons. Cost per ton.	Over 10 and less than 500 tons. Cost per ton.
Boston and Albany	Boston	6,143	44	$1 80	$1 80	$1 80
Norwich and Worcester	Norwich	51,621	60	1 75	2 00	2 25
Providence and Worcester	Providence	46,424	44	1 75	2 00	2 25
Total		104,188	..	....	....	....

Providence to Worcester should not exceed 92 cents, or $1.10, allowing a reasonable profit to the roads. The average charge during the last year appears to have been about $2.00 per ton, constituting a profit tax on warmth and power of nearly one hundred per cent.

The importance of this subject can best be illustrated by an individual instance. The Washburn Iron Company of Worcester receives old railroad iron and re-works it by a process of hammering and rolling, manufacturing car-wheels, locomotive tires and rails. Located as it is at Worcester, it must base all its calculations on being able to bring its coal to meet the old iron, at a less cost than the iron could be carried to the coal; it seeks in fact to make a profit by bringing coal to New England, instead of sending old iron to Pennsylvania. They consume about 18,000 tons of coal per annum, which is handled once by the railroads. Allowing the Providence and Worcester or Boston and Albany roads to charge 14 mills per ton per mile, the cost of one handling and fifteen per cent. of profit, amounting in all to 85 cents per ton, instead of perhaps $1.65, as at present, the annual power tax paid by this company would at once be reduced from $29,700 to $15,300, or by three per cent. on its entire stock capital. This may well make just the difference between success and failure. The city tax of Worcester for 1868 was $14.40 per $1,000 of assessed value. The Washburn Iron Company was assessed $218,200; if the city tax were permanently raised on this valuation from $14.40 to $80.00 per thousand, it would, most justly, be declared ruinous and the industry would leave the city. That identical increase is, however, now imposed in the shape of a transportation tax, and regularly paid under the name of freights on coal. It is unnecessary to dilate on the impetus which the reduction of this charge would communicate to the operations of the company referred to, or to estimate the increased amount of re-rolled iron, locomotive tires, car-wheels, travel and merchandise which would pass over the railroads in consequence of such an expansion.

No better illustration could be furnished of the harmony existing between the real interests of the community and its corporations. A cheap and abundant supply of all raw materials is at the root of the prosperity of each. For reasons which will hereafter be stated, no legislation can at this time be framed which will impose such a policy on the railroads, nor would it be wise to force it upon them were it feasible to do so. The Commissioners, however, confidently believe that not only will experience and reflection convince the railroads that the course suggested is the true one for them to pursue, but also that a more reflecting public opinion will compel them to adopt it, even though no recourse be had to the law-making power.

COMPARISON OF TURBINES WITH OTHER WATER-WHEELS.*

Translated from "Weisbach's Ingenieur-und-Maschinen Mechanik."

A great advantage of turbines compared with vertical water-wheels is that they work with any fall from 1 to 500 ft. (German), while the latter cannot convert into work the power of a fall of more than 50 ft. It is true that the ratio of effective work of turbines varies for different falls; for example, for small wheels it is less with high fall than with medium or low fall, because in this case the resistances are proportionally greater than with larger wheels under medium fall. On the other hand, overshot wheels obtain a modulus from high fall of from 20 to 40 ft., which cannot be reached by turbines. Equal amounts of work are to be expected from both kinds only from a medium fall of from 10 to 20 ft.; but if the fall is low, then turbines in every case give a greater modulus than undershot wheels under the same conditions. Poncelet's wheel can be compared with turbines for falls of from 3 to 6 ft. only.

Turbines have another great advantage over vertical water-wheels, in working with equal effect under different heads,

* Lehrbuch der Ingenieur-und-Maschinen Mechanik. Zweiter Theil: Statik der Bauwerke und Mechanik der Umtriebmaschinen (p. 668). This is the second part of Weisbach's book, the translation of which is now in press, to be published by D. Van Nostrand. Some idea of the completeness of the work can be had from the fact that the subject of Water-wheels occupies 285 pages, of which 153 refer to Turbines.

and especially in not being hindered by back water, so that they work in water as freely as in air, and in some cases with greater effect. Vertical wheels always lose power if the head varies, although in no great degree, unless the fall is low or the wheel is in the water.

On the other hand, variations in the overfall upon vertical water-wheels are attended with less loss of work than is the case with horizontal wheels. In an economic point of view this fact is in favor of the vertical wheel. If it is necessary to increase the effect of a vertical wheel already in motion, especially if it is one upon which the water acts mainly by pressure, it is done by supplying more water; and to diminish the effect the supply is partly cut off; in neither case is the actual modulus greater or less. The relation is altogether different in the case of a reaction-turbine. This works with most effect when the sluices are wide open and when the charge of water is the greatest; now if less work, and therefore less water, is required and the sluices are partially lowered, it happens that the work is diminished by decrease of supply, but partly by the loss of the living force of the water or by diminution of the head, so that the effective force is lessened. This destruction of living force may be compared with the braking or dragging of a wagon, which is applied in going down hill, when there is an excess of living force. Consequently, while the lowering of a gate only cuts off superfluous water from a vertical wheel, which can be used for other purposes; in the case of the reaction-turbine the shutting off a part of the overplus subtracts from the living force of the other part remaining in the wheel.

In pressure-turbines which do not run in water, so that the channels are not entirely filled, the modulus of work is more favorable, since the water issues through the channels without causing an eddy.

There is not a great difference between horizontal and vertical water-wheels in respect to the change of the velocity of revolution; in both, the normal velocity may be increased or decreased about one-fourth without material loss of effect. But there is certainly a very great difference in the magnitudes of these velocities. All vertical wheels, with the exception of the undershot (Poncelet's especially), have a maximum velocity of from 4 to 10 ft., while turbines generally have far greater velocities, varying greatly according to the heads. For this reason, and because they have smaller radii, turbines generally make many more revolutions than vertical water-wheels. It follows that the choice between these depends upon the number of revolutions; in other words, upon the kind of motion, quick or slow, which is required in the motor. But it must be borne in mind that rapid motion in a machine is rather injurious than advantageous, on account of the great increase of hurtful resistances, such as friction and shocks; for this reason it is often better to increase the number of revolutions by means of some machine of transmission, and to employ the vertical instead of the horizontal water-wheel.

If the load of a machine is variable, as in the case of tilt-hammers or rolling-mills, the vertical wheel is to be preferred; for, though it runs slower, yet on account of its greater mass it acts more as a regulator than the turbine, whose variable motion must often be equalized by a fly-wheel. But for a constant load preference must be given to the turbine in this respect; because vertical water-wheels, especially if of wood, often have a so-called "heavy quarter," *i. e.*, equal parts of the circumference are not of equal weight.

In an economic point of view, turbines rank at least equal with vertical wheels; and for high and medium falls and a great overflow, they are preferable because they are cheaper. In respect to durability, also, the turbine must have the preference.

On the other hand, it must be remembered that turbines require a clear overflow, and that their effect can be hindered in a very great degree by sand, mud, moss, weeds, leaves, pieces of ice, twigs of trees, etc., which do no damage to vertical wheels. Finally, it is to be considered that turbines, particularly those with guide-curves, are more difficult to construct, and that departures from the mathematical rules of construction are followed by worse results than in the case of vertical water-wheels. This is the reason that so many turbines failed in the early trials, and that they are not yet as extensively employed as their advantages warrant.

The Sutro tunnel has been bored seven hundred and fifteen feet.

METHODS OF SURVEYING.

By E. SHERMAN GOULD, C. E.

There are several ways in which the form and area of a tract of land may be ascertained.

One method is by means of the chain alone. If the plan of any flat surface be examined, it will be perceived that it is possible to form upon it such a system of linear measurements as shall, irrespective of the value of the angles, determine the shape of its contour, and no other shape—the two conditions necessary and sufficient for the purpose proposed. It would be perceived, in such a plan, that the determining network consisted mainly in a system of triangles; the triangle being the only geometric figure the form of which is precisely defined by the dimensions of its sides, independently of those of its angles. It would be seen, moreover, that when the figure is not decomposed entirely into triangles, but is made up of triangles and trapeziums, it is necessary, in order that the figure be defined, that the trapeziums fall on the sides of the triangles, or on the sides produced.

From these considerations we deduce the following principles: First, that a chain survey is not practicable unless the tract to be surveyed admits of being decomposed into a sufficient number of triangles to tie the rest of its component parts together; and, secondly, that when accuracy in the computation of the area is desired, the entire figure must be reduced to triangles, having no trapeziums to be calculated off the plot. The determining triangles should be of large dimensions, proportionally to the size of the the tract, for mere tie lines do not afford a sufficient degree of accuracy.

I have said this much of chain surveying in order that its principles may be understood. Practically, it is a mere makeshift, to be used only when accidentally unprovided with instruments. It is neither so accurate nor so expeditious as when an angle-measuring instrument is employed in connection with the chain. In extensive surveys, obstacles will prevent correct alignements, and the whole work will be rendered uncertain.

The two methods of instrumental surveying are: *the system of co-ordinates* and *the system of traversing.*

By the first of these methods the form of the tract to be surveyed is determined by the location of a series of points on its contour, in reference to a *base line*, which may be one of the lines of the tract itself, but which is ordinarily an entirely independent and arbitrary line. The principle of this method is the same as the mathematical determination of a curve by the value of its *co-ordinates*, and I have presented the name for this method of surveying—there being, I think, no better introduction to the application of mathematical analysis to practical purposes than the familiarization of the mind with the actual signification of its technicalities.

Surveying by co-ordinates comprises two varieties: the one in which the co-ordinates are determined solely by the angles which they form with the base, and the other in which their linear as well as their angular dimensions are taken. Of the first of these I will not speak; its use is confined to the extensive triangulations executed for Government surveys, and is rarely applicable to ordinary purposes—for one reason, among others, that the success of such a survey depends on measuring the base line with a degree of accuracy unattainable with ordinary instruments.

The execution of a survey by the second variety of this method is exceedingly simple, especially when the co-ordinates are rectangular. Distances are measured on a base, to locate points whence to erect perpendiculars to the boundaries; and these perpendiculars, being measured, determine so many points on the contour, the minuteness of the survey depending upon the number of co-ordinates taken. When perpendiculars cannot be conveniently erected, recourse must be had to *oblique co-ordinates*. It will be seen that this method is chiefly applicable to cases where the distance from the base to the boundaries of the tract is comparatively small, otherwise the length of the ordinates, or offsets, would become excessive, and demand too much time and labor to measure.

The advantages of this method are:

1st. Its simplicity, both in the field and office work.

2d. Its general accuracy, which arises chiefly from the fact that any error in the measurement of an angle or distance does not affect the general result, being confined to that single observation.

3d. It accomodates itself to either minute or superficial work. By multiplying or diminishing the number of offsets, any desired degree of detail may be obtained, from a mere skeleton to a figure approaching the completeness of a mathematical integration.

4th. All the ground between the base and boundaries is taken cognizance of, as the points at which roads, streams, etc., are crossed may be measured on the ordinates.

All these advantages in the field work hold good in the office. It will be readily perceived in how convenient a form for plotting the field notes are taken, and the degree of accuracy in computing the area can be varied, as in the field work.

The disadvantages of the system are: 1st. That the work cannot be checked by closing. This difficulty, however, is rendered almost nugatory by the little likelihood there is of an important error being made, particularly when secondary offsets are taken, these serving as checks on the main co-ordinates. 2d. That it necessitates a previous knowledge of the "lay" of the land, in order to locate advantageously the base line and ordinates. 3d. That it requires generally the penetration in all directions of the tract to be surveyed, which is not always practicable.

The method by traversing consists in going around the tract, measuring the length of each side, and the angle which it forms with the one preceding it, or taking the distance and bearing of each side, if the instrument used be the compass.

The advantages of this method are, that it is applicable to any tract of land, of no matter what shape, and does not call for a knowledge of its lay. No reconnoitering is necessary, and the lines are "taken along" as you advance. In fact, by this method a survey may executed, checked, described, and the content calculated, without the surveyor ever knowing the exact shape of the tract surveyed. Its chief characteristic is, that the bounding lines are dealt with directly. These lines are naturally rarely obstructed by artificial obstacles, such as buildings, orchards, etc., and are therefore comparatively clear. Moreover, as such lines are generally intended to be perpetuated by a ditch or fence, the felling of such trees as may stand upon them is ordinarily permissible, which is not the case in running a purely arbitrary line, like a base or offset, through the middle of an estate.

This system is the one almost exclusively employed in this country, where indeed a method describing boundaries simply by their relations to each other, or by their bearings, is often indispensable. In England the system is but little pursued, probably because, in that thickly settled country, boundaries can always be fixed by well-known land-marks.

The radical defect of the system is its liability to lead to inaccurate results if the most minute precautions are not taken in the execution of the field work. Every line dates from the one preceding it (when the transit is the instrument employed), and a mistake in one not only affects all, but goes on increasing through the entire survey.

NITRO-GLYCERINE EXPLOSIONS.—Much of the mystery that has surrounded the cause of many of the nitro-glycerine explosions, is now explained by the recent observation of M. Jouglet, who positively asserts that this compound, however carefully and well prepared, is subject to spontaneous alteration, whereby it becomes acid and disengages gas. This is doubtless the clue to the fearful explosions so frequently and unaccountably accompanying the storage and transportation of this material, and it at once suggests the true preventive of their recurrence. It should only be made on the spot when wanted, and in such quantities as its immediate use demands. Legislation is demanded in this country towards this end, as it has already been in England and some countries of continental Europe.

AN excellent material for uniting water-pipes is prepared by combining four parts of good Portland cement and one part of unslacked lime, mixed together in small portions in a stout mortar, adding enough water to permit it to be reduced to a soft paste. Pipes thus united have been in use more than six years without repairing.

THE SECOND PERSIAN GULF CABLE.

From "The Bombay Gazette."

It may be remembered that more than a year ago the Government decided to submerge a second telegraph cable in the Persian Gulf, extending from Bushire to Jashk, on the coast of Mekran. At the present moment there is a double line of communication from Kurrachee to Jashk, the one by submarine, the other by aerial telegraph; and from Bushire to England there is the line by Turkey (just now unfortunately interrupted by the Arabs), and a second through Persia and Russia —the organization of which, at Messrs. Siemens' hands, will not, in all probability, be thoroughly carried out until the end of November. The laying, therefore, of the second cable between Jashk and Bushire will complete the duplicate chain of communication between India and Europe, and will relieve the old cable from a weight of traffic already nearly too much for its capabilities.

So far back as July, 1868, the manufacture was commenced in England, under the management of Mr. Latimer Clark, who was engaged to superintend the construction and submersion of the new cable. The general direction of the arrangements was intrusted to Major Champain, assistant to Colonel Goldsmid, the head of the Indo-European Telegraph Department. This is the first cable of importance where the old gutta-percha covered core has been discarded, and india-rubber, prepared by Mr. Hooper, the well-known chemist in Pall Mall, used in its stead. The superior insulating properties of the latter substance have long been recognized; but difficulties in properly preparing it, and numerous other causes, have hitherto prevented its general adoption. The excellent qualities of Hooper's core have, however, been satisfactorily proved by many severe tests. An experimental length has for a long time been laid near Bushire; the new core was also used for the existing Ceylon cable; many miles have been sent out to India for river crossings; and a considerable quantity was purchased and sent out in 1867 for telegraphic purposes during the Abyssinian campaign. The cable under consideration was covered by Mr. Henley, of North Woolwich, and shipped last winter on board the two fine-sailing vessels, the Tweed and the Calcutta. It was at first intended to lay the new line in the spring of the present year; but the whole arrangement had to be altered in January, in consequence of the disastrous collision of the Calcutta near the Lizard, when seventy miles of the cable had to be thrown overboard, and the vessel at last abandoned in a sinking state in Channel. The captain of the Calcutta and thirty of his crew, including three cable hands, lost their lives; but the ship was eventually picked up and towed into Plymouth by her Majesty's frigate Terrible. The seventy miles of jettisoned cable were grappled and recovered under the immediate supervision of Mr. Webb, Mr. Latimer Clark's assistant, and after great labor the Calcutta was able to sail again at the end of June, closely followed by the Tweed.

Both ships reached Bombay on the same day, and are now lying off the Apolla Bunder, preparatory to the final start for the Persian Gulf.

It was from the first determined to lay the cable out of sailing vessels in tow of steamers—a plan which involves some risk, and which is never adopted in latitudes where settled weather cannot be counted on. In this instance the vessel actually paying out will be towed by the Dacca, a steamer just chartered for the expedition by the Bombay Government. The second vessel will be towed by the Earl Canning, and the Amber Witch has already started for Jashk, to lay the shore ends in advance. The original length of 525 miles of cable shipped has been reduced by ten miles, in consequence of loss in splicing and repairing the seventy miles jettisoned off the Lizard. The operations will commence about the 1st of November, and the cable will be laid up the gulf from Jashk to Bushire, the Tweed first paying out her stock and the Calcutta completing the last half to Bushire. It is confidently expected that the ships will be back in Bombay by the beginning of December, to have their tanks removed and their decks and beams replaced.

TRUE BASIS FOR THE CONSTRUCTION OF HEAVY ARTILLERY.

By LYNALL THOMAS.

(*Continued from page* 317.)

It has been assumed that the proper charge for a gun of given calibre should be proportional to (that is, as the cube of) the calibre; and so it might be were the effect produced by the repeated action of the charge on that portion of the chamber where the force of the charge attains its greatest magnitude relatively the same in guns of every calibre. But my experiments showed that this was far from being the case.

It is not the general pressure of the inflamed gas over the whole surface of the chamber, so much as the degree of energy expended in particular parts of it (or the magnitude of the strain at a given point at a given moment), which bursts or destroys a gun; and the latter I found by experiment to rise so rapidly in magnitude with any increase in the calibre of the gun (the charges being proportional) as apparently to preclude the employment of proportional charges, especially if the charge employed with the gun taken as a standard is the maximum charge which that gun is found to be able continually to bear.

Before the introduction of rifled ordnance, when round shot were exclusively used, it was necessary with guns of every calibre to employ charges proportional to the weight of the shot, or as the cube of the calibre, since the weight of the shot increased in that proportion; and if smaller proportional charges had been used with guns of larger calibre, the velocity of the shot, since the weight could suffer no reduction, would continually have been reduced, and the effect proportionally diminished.

And this method, up to a certain limit, could be carried out, because the charge necessary to give a 6-lb. or a 9-lb. shot its proper velocity (that is to say, the highest which it would practically bear with advantage) was so much smaller than a gun of its calibre and strength would actually bear. But smooth-bore guns having been apparently constructed on the "rule-of-thumb" principle, that is to say, as guns of different calibres were nearly all of the same relative proportions, the limit was soon attained; for we find that the charge for a 68-pounder gun, which is of about double the calibre of a 9-pounder gun, had a service charge of 16 lbs. only, whilst that of the 9-pounder being 3 lbs., it ought to have been 24 lbs.; and it is a remarkable fact that although the service charges for smooth-bore guns were in the proportion of the cube of the calibre, the proof charges were nearly as the square of the calibre only.

Now, nearly the whole of the conditions are different with rifled cannon, the weight of the projectile (within certain limits) being optional, as well as that of the charge of powder.

An entirely new element is thus introduced into all calculations relating to the construction and service of heavy artillery; namely, the proper regulation of the charge, first, with regard to the respective proportion of powder and shot, secondly, as to the quantity of either which can be used with the greatest advantage in guns of different calibres.

The actual effect of the charge and the proper thickness of metal (of a given quality) are the two essential points to be considered in the construction of heavy rifled ordnance.

In these days, when guns of great penetrating power are required, the proper regulation of the charge to the calibre of the gun is of the utmost consequence; and I think it will be generally admitted that the right charge to employ with guns of all calibres is the greatest that they will bear consistently with their endurance, not only as against actual disruption, but with regard to the effect of the repeated action of heavy charges on the surface of the bore, which will vary with the quality of the metal of which the interior of the gun is constructed.

Some years ago I carried out a set of experiments for the purpose of ascertaining, if possible, what was the maximum charge which steel rifled guns of different calibres would bear without injury; for a charge may be heavy enough, without absolutely and at once bursting the gun, to injure the interior or surface of the bore to such an extent that the repeated discharge of such a quantity will eventual-

ly cause the premature destruction of the gun, and (since the charge for guns of all sizes should be of a relative quantity, which shall allow them all to endure an equal number of rounds or discharges) must therefore be considered as too heavy for ordinary use.

The comparatively large quantities of powder which I found could be fired from tubes of small diameter, at first greatly astonished me. Charges of more than 5 oz. (with a round ball) were repeatedly fired in a tube ¾ in. in diameter (the size of the old musket-bore, the charge for which was 4½ drachms only) without causing any apparent damage, and of 1½ oz. with cylinders of over 7 oz. in weight. (I may state that the tubes were of a strength which insured them against actually bursting.)

For a moment I fell into the error that, beyond a certain quantity, the magnitude of the charge of powder could not be of the consequence I had supposed it to be, but was quickly undeceived; for, on further experiment with tubes of larger diameter, I was equally surprised to find that the length of the tube or bore occupied by the powder (the projectiles being of proportional weight, *i.e.*, as the cube) could not be materially increased. Instead of a quantity in the proportion of the cube of the calibre, it was found that a quantity proportional about to the square of the calibre only, was as much as the interior would apparently bear without injury.

The conclusions which alone could be formed from the above-named experiments coincided so nearly with those to which I had then already been led by observed results in a different set of experiments (on the action of gunpowder in chambers only) as to leave very little doubt on the subject. And if I have correctly estimated the results of these experiments, the proportion in which the charge ought to be reduced with any increase in the calibre is self-evident.

The limit for the charge will of course vary with the limit of endurance of the metal of which the interior of the gun is formed; the standard, therefore, will be raised or lowered with the quality of the metal, with the quality of the powder, and even with that of the metal of which the projectile is made. A general improvement in the quality of all these will tend therefore to greatly increase the power of heavy artillery.

If we are ever beaten by foreigners in the manufacture of heavy ordnance, it will be owing to the superior quality of their metal. The application of the twisted barrel (similar to that of the fowling-piece) to cannon was, no doubt, an excellent idea, and presents many advantages, but does not appear suitable for the inner surface of heavy guns, as not bearing well the repeated action of heavy charges and great friction, and is not in that respect to be compared with a hard close-grained homogeneous metal, like Krupp's steel, for instance.

If this is found to be so, the new 10-in. (18 ton) gun is not likely to prove eventually successful, since the charge which it is to fire (60 lbs. of powder and a 450-lb. shot) is equivalent, if I have rightly estimated the results of my experiments, to a charge of at least 24 lbs. of powder and a shot of 180 lbs. weight fired in a 7-in. gun. Supposing, therefore, that the service-charge for the latter gun, from 14 lbs. to 22 lbs. of powder and a 115-lbs. shot, is as much as the gun will continually bear, it is evident that the above-named charge for the 10-in. gun, as it must produce a comparatively greater strain on the gun, is too great.

In fact, if attempts are made to fire the same proportional charges which were formerly used with smooth-bore guns, namely, in the proportion of the cube of the calibre, either a different quality of powder or a different quality of metal will be required for every class of gun!

A knowledge of the law which regulates the action of the charge, and by means of which alone it is possible to form a correct estimate of the relative effect produced in guns of different calibres by both the powder and the projectile, is as necessary for the proper construction of a gun as is a knowledge of the laws of hydrostatics for the construction of a ship.

To the absence of this knowledge is due the enormous expenditure incurred during the last ten years in gunnery experiments. To it, no doubt, may be attributed the failure (which has been spoken of) of the attempt to apply the method proposed by Sir William Armstrong to large guns. The fact is, however, that the old system or theory was on its trial and signally failed; and whether applied in the case of

the Armstrong or any other method of construction, the results must have been equally disastrous.

Who could possibly form an opinion, for instance, as to the respective merits of the turret and broadside systems for ships of war, if so little regard were had to the laws of hydrostatics in their construction as to cause both but imperfectly to fulfil the proper conditions of ships at all?

The whole proportions of a gun are entirely dependent on the effect produced in the gun by a given charge of powder and weight of projectile; and of both the actual and relative magnitude of the effect in different guns the authorities, when first attempting to construct heavy rifled cannon, were confessedly ignorant. No formula for their construction was even attempted to be used; how, then, was it possible, except on the vaguest chance, to hit upon the proper method either for the construction or employment of heavy rifled cannon of any kind? It was proved to be impossible; hence the fruitless expenditure of so many millions.

As an example of the necessity, in gunnery experiments, of a previous knowledge of the law to which the action of the charge is subject, and the lamentable consequences which must ensue from neglecting or ignoring it, I may mention the attempt to strengthen (with a view to their conversion into rifled guns) the old 32-pounder smooth-bore service-guns, by placing a wrought-iron tube upon the exterior of the gun, so as to encase the breech part of it. The experiment failed, of course. It cost the country £45,000, which a little knowledge would have saved, numbers of these guns having been "strengthened" before the error was discovered, no preliminary experiments, apparently, having been made. Major Palliser, who has the reputation of being a scientific artillerist, and who at an early date had observed that the theory I had put forward respecting the action of gunpowder was borne out by experiment, placed the wrought-iron tube in the interior of the gun, and thereby added enormously to the strength of the latter. This may be understood by supposing that, were it necessary to protect a block of cast-iron from the effect of a shot's impact which would tend to split it, it is evident that a plate of wrought-iron placed at the back of it would prove no protection whatever, but that placed in front of it, where it could receive the first blow, it would effectually protect it.

The point at issue all along has been that the authorities have maintained that there is no law for the effect produced by the charge in a gun. The very nature of their experiments has proved that they hold this opinion, and that, necessarily, every class of gun must be made the subject of a costly set of experiments before it can be ascertained whether its proportions, charges, etc., are correct or not. "For every gun, no matter what its construction, there is a proper charge," was the opinion expressed to myself by one of the chief authorities in the War Department. It might as reasonably be said "for every ship there is a proper armament; it is useless, therefore, in building ships of war, to calculate beforehand what guns they are to carry; we shall find that out after they are launched!" And fancy no law or rule to exist by means of which this matter could possibly be calculated beforehand, and that every class of ship had to be the subject of experiments for years before the plan of its construction was decided upon! Yet this has been the case with our heavy artillery. And when it is considered into what an infinite variety of forms a given quantity of metal may be fashioned in its conversion into a gun, the expense, as well as the futility of making the gun itself the sole object of experiment, is apparent.

I have always maintained, on the contrary, that it is the effect produced by the charge to which experiment ought first to have been directed. The gun is merely the vehicle for the discharge of a shot of given weight with a given charge of powder. And if the proper laws are observed in the construction of a gun, of whatever kind it may be, that mode of manufacture is the best, no matter whether Frazer's, Whitworth's, Armstrong's, Palliser's, or Krupp's, which will allow of the employment in a gun of given calibre of the highest standard for the charge.

It was with the view of attempting to prove the truth of what I had advanced, as well as to show the great power attainable with heavy rifled artillery, firing charges in conformity with the results obtained in my experiments, that I had the first 7-in. and 9-in. guns constructed.

The 7-in. was the trial gun. The principle upon which it was constructed was

so novel, and the whole undertaking deemed so rash, putting aside the facts that so heavy a gun (6½ tons) was said to be perfectly useless (since no ship could ever be made to carry them), that no rifled cannon larger than a 40-pounder Armstrong gun was ever likely to be used, and that a gun of this size even had not yet been successfully made, that I was informed that I must undertake the whole cost at the risk of an entire loss in the event of failure. Notwithstanding the large sum I had spent upon it, and the sinister prognostications that the shot could never be got out of the gun, I fired at once charges of a quantity relatively very much in excess of any which had ever been attempted previously in any kind of gun,—the smooth-bore gun of that calibre firing charges of 14 lbs. with a 42-lb. shot only.

The charges were from 23 lbs. to 28 lbs. of powder, and the shells (expanding) of 175 lbs. weight*; and the practice at once showed the enormous results attainable with guns on this principle.

The gun, which was of steel and forged in one piece (the largest which had ever been attempted), was unfortunately found to be defective in the breech, and at the second trial burst whilst firing a charge of 21 lbs. only; and I lost a large sum of money by it, as the repayment of my expenses was on this account refused.

I have not referred to this trial, however, for the purpose of detailing my own grievances, but to show that the principle was correct, since subsequent trials with guns constructed in conformity with it have proved so successful that, singular to say, a gun of the identical weight and calibre is now adopted into the service, the only difference being that the charges are not quite so high as those I first proposed, which were from 20 lbs. to 25 lbs. of powder, the highest charge used with the 7-in. service-gun being fixed at 22 lbs. and a shot of 115 lbs. weight. Unhappily, the authorities were unable at that period to appreciate the importance of the results which attended the trial of the 7-in. gun, chiefly from the fact that they were totally inexperienced in all that related to heavy rifled ordnance. Unfortunately, too, our gunnery experiments were begun at the wrong end, attention being chiefly directed to merely mechanical improvements before a sound principle had been established as a basis to work upon. Hence the enormous expenditure which they have occasioned of late years.

It is far from my wish to impute blame to any person, but no one can doubt that a great error was committed and lack of judgment displayed in the first instance.

The old "rule-of-thumb" principle was all very well when applied to cast-iron guns of comparatively small weight and power; but the attempt which I first made (in conformity with laws obtained from previous experiments) in 1858 to introduce heavy rifled guns firing huge cylinders with large charges of powder, caused a complete revolution in artillery by introducing entirely new elements for consideration, which rendered it absolutely necessary that some fixed laws should be established, both for the construction and use of these guns; and when we consider that there is scarcely a single law in dynamical science which is not involved in this question, it may be imagined how necessary this must be, and also how expensive and profitless experiments with this kind of ordnance must be (since no correct estimate can be formed of their value) until this has been satisfactorily effected.

Our enormous expenditure in experiments with heavy rifled guns may be said therefore to have chiefly arisen from the circumstance that, instead of those experiments being primarily directed to the establishment of sound fundamental principles, they seem to have had for object simply the improvement in the actual mode of manufacturing cannon, a course which has been more profitable to the manufacturers than to those who have had to pay the expenses; consequently attention has been mainly attracted to niggling mechanical details, upon which any given sum may be frittered away, and which, after all, are only of secondary importance. When once a sound basis has been obtained to work upon, mere mechanical experiments work themselves out in

* Expanding shot are productive of greater strain on the gun, though not to the extent usually supposed; for although an apparently large pressure is necessary simply to push them through the bore, yet as a comparatively slight but sudden blow will drive in a nail which would resist a large pressure, so the force of a charge of powder, being percussive, drives out the projectile by an action the value of which cannot be estimated by any given number of pounds weight. In fact, it is questionable whether the strain produced by expanding shot (of soft metal) is in any degree greater than is due to the circumstance that with such shot there is a complete absence of windage.

the course of practice; but if guns are constructed on a principle which is fundamentally wrong, however admirably the mechanical details of their manufacture may be, proper results are absolutely unattainable with such.

The authorities point with satisfaction to the mass of heterogeneous results obtained during the experiments of the last ten years, as if they had thereby exhausted the subject; but of what, may I ask, have they been productive?

As a proof of the small value of mere results, and of the errors even to which they may give rise unless judged on sound principles, I may cite the following:

In 1862, Lieut.-Col. Boxer, of the Royal Artillery, wrote a pamphlet, entitled "Remarks on the system proposed by the Royal Commissioners for the Defence of the Country," which was replied to in another pamphlet by Colonel (now General) Lefroy, R. A., President of the Ordnance Select Committee. In the former, certain statements were put forward with regard to the effect producible theoretically by projectiles of equal weight, but different diameter, on iron plates; which Colonel Lefroy attempted to show were contrary to the results obtained in experiment, and therefore erroneous.

"Perhaps (remarks Colonel Lefroy) the best way of showing the fallacy of the assumption that the penetration of two shots into wrought-iron, the *vis viva* being equal, will be inversely as the squares of their diameters, is to see to what this assumption leads.

"Suppose the 110-pounder shot reduced in diameter to 3 inches, *i. e.*, to take the form of a cylinder nearly of the weight of ten shots fired from a 12-pounder gun, but with such a charge as will give it the same velocity of impact as before. According to this rule, its penetration should be 5.3 times as great; now the mean penetration, or denting, of wrought-iron by the 110-pounder shot at 200 yards is 2.1 in.; we are entitled, therefore, to assume that such a bolt will produce a dent of 11.2 in., and of course *go through* a greater thickness of iron, just as the 110-pounder would go through more than 2.1 in. Lieut.-Colonel Boxer can maintain no such absurdity, and he is well aware that the work of the blow would be mainly done on the shot itself, which would go to a hundred pieces, while the effect on the plate would be probably but little greater than that of the common 12-pounder shot. * * * * Hence a 110-pounder shot reduced to a diameter of 13 in., would produce very much *less* effect than in its original form with a diameter of 7 in., the reverse of what Lieut.-Colonel Boxer would lead his readers to expect."

The above affords an excellent instance of the truth of what I have stated. Col. Boxer based his arguments on a well-established scientific law; Colonel Lefroy, on certain results he had witnessed in experiment.

Colonel Lefroy, being President of the Ordnance Committee, it may reasonably be supposed that the 10.5 in. (300-pounder) 12-ton gun was constructed in accordance with the above-named experimental results. Let us suppose, therefore, that at that point all Government experiments had ceased, and the order had gone forth to construct the whole of our rifled ordnance on the plan of the above-named guns—that is, in conformity with the experimental results already obtained; what would have been the consequence? We should have made an enormous outlay in the acquisition of guns on a totally wrong principle, and been years behind the rest of the world; for the very next year my first 9-in. gun, firing charges of from 40 to 50 lbs. of powder and shot of proportional weight, was fired with the Government 10.5-in. gun for the first time against 7¼-in. plates (steel shot of equal weight being employed with both), when the penetration of the 9-in. shot was 10½ in., whilst that of the 10.5-in. gun was 6½ in. only.

A few years later Major Palliser brought out his chilled shot, when the comparative penetration of projectiles of small diameter was greatly increased. How, then, may it be asked, could the actual results of experiment have been apparently at first so directly opposed to those established laws upon which Colonel Boxer grounded his arguments, and which subsequent experiment tended to confirm? Simply because the first results were misjudged; since, instead of proving (as inferred by Colonel Lefroy) that with projectiles of the same weight those of larger had greater penetrating effect on iron plates than those of smaller diameter, they proved merely that the metal of which the pro-

jectiles were composed was of too soft or too friable a nature to admit of their being projected with a force sufficient for the purpose; consequently the smaller the diameter of the shot compared with its weight, the more apparent was this defect, and the greater the visible damage produced by the impact of the shot of larger diameter.

Colonel Boxer therefore was perfectly right in taking the grounds he did, and Colonel Lefroy's experimental results no more tended to overthrow his arguments than would the results obtained by firing a Dutch cheese against iron plates; it would simply have been a question of the degree of hardness of the projectile; and this shows how very much more important is the establishment of a single scientific truth than the mere acquisition of millions of undigested results acquired in desultory experiments.

FILTERING AIR.

From "Engineering."

Everybody is familiar with the sight of "motes dancing in a sunbeam," and there are probably few people who have not at some time or another, when looking at these minute particles, reflected that the air we breathe is apparently rather a dirty mixture, after all. And—to a certain extent—people are perfectly right when they make this reflection. The air in all towns, and, to some smaller extent, in the open country also, is impregnated with these minute atoms, invisible in ordinary diffused light, but revealed when exposed to a powerful beam of solar or other light, by the dispersion of this light to which they give rise. Until about eighteen months ago it was generally believed that these minute particles consisted of inorganic matter, and that they were indestructible by the ordinary process of combustion. In October, 1868, however, Professor Tyndall, who was at that time experimenting on the decomposition of vapors by light, discovered that air, when allowed to pass through the tip of the flame of a spirit lamp, was deprived of these floating particles, the latter being in fact consumed, thus showing their organic character. Prior to this discovery, Professor Tyndall had endeavored to filter the air of these atoms by passing it successively through two glass tubes, the one containing fragments of glass moistened with sulphuric acid, and the second fragments of marble moistened with caustic potash; while in other cases he had allowed it to bubble up through the liquid acid and through a caustic potash solution. In both instances, however, the air passed through carried with it the minute particles, these being clearly revealed by the light of a condensed beam. Having discovered, however, that the atoms could be burnt up by being made to traverse the flame of a spirit lamp. Professor Tyndall substituted for the latter a roll of platinum gauze, placed in a platinum tube and ignited to redness; when he found that equally good results were obtained, the air being cleared of its floating impurities. But the air can be filtered of its floating particles by other means than by combustion, and Professor Tyndall has found that a thoroughly effective filter for this purpose is formed by a layer of cotton wool, not too tightly packed—a form of filter, we may add, that was first used by Schroeder, in his experiments on spontaneous generation.

But, it may be said, this is all very interesting, no doubt; but what has it to do with engineering? We answer—a great deal. Of the many branches of our profession there is none of greater importance than that dealing with sanitary questions—such, for instance, as the disposal of sewage, ventilation, and subjects of a kindred nature. In a civilized community, life itself depends upon the satisfactory solution of the problems which these subjects involve, and there is certainly no necessity for us to enlarge upon their importance here. Now, Professor Tyndall has shown that the atoms floating in the air are of an organic nature, and he has, moreover, shown that when air is passed through the lungs, it is to a certain extent deprived of these atoms, a portion of the latter evidently having been retained within the lungs themselves. Moreover, in an admirable lecture on "Dust and Disease," delivered by him at the

Royal Institution, on Friday last, he has shown—reasoning from analogy—that there is a strong probability of what is known as the "germ theory of epidemic disease" being, at all events to a great extent, correct. According to this theory, which, proposed many years ago, was at one time treated with strong opposition and ridicule by the medical profession—epidemic diseases are propagated by floating germs which enter into the system and give rise to parasitic life. Supposing this theory to be correct, and, as we have said, there are strong reasons for supposing it to be correct to no small extent, it evidently becomes one of the first duties when endeavoring to prevent the spread of disease, to deprive the air of these floating germs by some process of filtering. And here we may remark that this filtering process is almost instinctively resorted to by our medical men, it being a common thing for a physician, when visiting a patient suffering from a contagious disease, to place a handkerchief to his mouth and breathe through it. To some extent, this handkerchief, as has been shown by Professor Tyndall, answers the purpose of cotton wool filter, depriving the air of its floating atoms, and allowing it to enter the lungs in a pure state.

But even if an epidemic was raging amongst us, the majority of people would object to go about with a handkerchief over their mouths, or wearing a cotton wool respirator, and indeed the ordinary demands of business would prevent these precautions from being generally resorted to. It is here, then, that the sanitary engineer steps in to the aid of his medical brethren, it being his duty to do on a wholesale scale that which personal safety would require each individual to do for himself. In other words, supposing the germ theory to be true, it is his duty to filter all air escaping where disease is active, or where the germs exist, thus preventing the dissemination of the latter, and hence the propagation of disease. Thus the ventilating flues of hospitals devoted to contagious diseases, the openings of sewers, etc., should be guarded by filters which will arrest these germs, while it is probable that in the ventilation of churches, schools, or large public buildings, also, the air admitted and discharged might be advantageously submitted to the filtering process.

Of what the filters could be best composed, it is as yet impossible to say. The cotton wool filters, shown to be so effective by Professor Tyndall, might be employed in some cases; but in a vast number of instances there would probably be practical objections to their use. The efficiency of the cotton wool filters is likely to be due to the enormous collecting surface which the filaments of cotton, contained within a moderate compass, expose, and it is not unlikely that charcoal or other filters, such as are now used, would, if made so as to expose an equal amount of surface, act equally well. So far as we are aware, however, no experiments have yet been made upon the power of charcoal to retain the atoms floating in the air, but the experiment is easily made, and should be carried out without delay. In some cases the passage of the escaping air through fire, already a well-known disinfectant, or over highly-heated surfaces, may prove the most convenient mode of treatment; but where the air has to be purified before admission to a building, this plan is manifestly not applicable. The action of vegetation on air charged with atoms, is also highly deserving of investigation, and such an investigation might do much to dispose of the objections which have been urged against sewage irrigation.

The test of the efficiency of a filter, of course, is that the air issuing from it shall, when traversed by a powerful ray of light, not render that ray visible to an observer standing out of the line of it. In fact, air cleared of its floating atoms is not illuminated, in the ordinary sense of the term, by a passing ray, and a current of such air, when caused to cross a sunbeam, which is passing through ordinary air charged with atoms, appears to break the continuity of the beam, the current, which is clear of atoms, showing on the beam like dark smoke.

We have devoted considerable space to the matter of which we have been treating, because—notwithstanding that the "germ theory" is not yet a firmly established fact, and hence the benefits derivable from filtering air not yet decisively proved—the subject is one of such vast importance that it cannot be too widely or too thoroughly discussed. That our sanitary engineers have already done very much to restrain the spread of disease, we

are quite ready to admit, but the terrible records published year after year by the Registrar-General, prove that there is yet much to be done, and everything that tends to the completion of this great work is worthy of sincere encouragement.

THE ISTHMUS OF CORINTH.

From "The Engineer."

Perhaps, as a rule, it is not generally admitted or recognized by engineering students, as well as by other professional *alumni*, that physical geography is a very interesting and instructive science. To the unlearned and uninformed a glance at the map of the world reveals nothing but a somewhat chaotic distribution of land and water. The mutual relations and the several positions of the "dry land," and "the gathering together of the waters," appear to be accidental, and at first sight there is no evidence of any method in their respective arrangement. But a very slight acquaintance with the science to which allusion has been made, will demonstrate the fallacy of such an opinion; and indicate in unmistakable language that the physical contours of our planet have been determined by the unerring laws of nature. As a corroboration of our assertion, it is quite sufficient to mention the general uniformity that is to be observed in the shape of continents and large masses of land, which are laterally extended towards the north and contracted in the south. It is well known that whatever other grounds Columbus might have had for believing in his own mind that the New World existed, his belief was materially strengthened by his knowledge of physical geography. An attentive observation of the manner in which the land and water was arranged, and the balance of matter maintained, led him to the conclusion that there must be a large mass of land somewhere in the Western hemisphere, to counteract the influence of so extensive an area of water. The result of his reasoning was the discovery of America.

Regarded in the abstract, it is scarcely possible for the comparatively insignificant efforts of man to alter the physical appearance of the globe. In one sense, however, they do very materially change the face of the earth, and there is very little doubt but that it is a mission of the human race so to do. It is true that our power is limited. We shall never fill up the Atlantic Ocean, nor level the Himalayas, but we do form rivers, destroy enormous forests, and drain lakes. Nothing would be easier than, by making a communication with the nearest ocean, to convert some of the most beautiful and fruitful valleys of the world into inland seas, and make them like unto Sodom and Gomorrah. There is neither presumption nor the least approach to profanity in asserting that modern engineering is the only art that makes "the crooked straight and the rough places plain." The argument that "the end justifies the means" has always been regarded as rather of a Machiavellian character, nearly identified with doing evil that good may come of it, and by no means a safe maxim to instil into the minds of youth. It is, nevertheless, astonishing how sometimes the end does justify the means, and how success is invariably regarded as the test of merit. This has been remarkably exemplified in the completion of that great work, which will deservedly entitle the name of de Lesseps to be recorded in the historic archives of every kingdom under the sun. Henceforth the means of executing similar works will be disregarded; the motto will be *Finis coronat opus;* and a mania will arise for cutting through isthmuses, which will give employment to every navvy that can handle pick and shovel. The physical subdivisions of the land will consist in future of islands only. What joy for the rising generation and the pupils of national schools! Continents, isthmuses, and peninsulas will be banished from the text-books, and juvenile brains will be no longer puzzled to comprehend the several distinctions.

At this particular moment, when the opening of the Suez Canal has attracted universal attention towards all those narrow necks of land which divert vessels from a direct course, it cannot fail to strike one that the railway has not altogether superseded the canal as a means of international communication. In the instance

before us we have railway and canal occupying the same territory. Were the executive of a Government always equally quick in its operations as the administrative department, the modern Athenians would be the first to follow the example of M. de Lesseps. The Hellenic Parliament is in deliberation respecting the cutting through of the Isthmus of Corinth, the tongue of land which is situated between the gulfs of Athens and Lepantus and unites the classic mainland with the shores of the Morea. By its geographical position, this isthmus bars the union between the Adriatic and the Archipelago, and obliges all vessels passing from the one sea to the other to round Cape Matapan. Its existence materially lengthens the voyages of all ships bound from the western parts of Europe to the Levant, to Syria, Asia Minor, and to Smyrna. The last-mentioned port is the emporium to which the numerous caravans from the interior of Asia, from Persia, and the Caucasian regions, transport the rich products of oriental countries still more distant. In a similar manner it exercises a protracting influence upon the route from Europe to the Black Sea, which is a matter of serious importance, as from the ports on the latter are exported the enormous quantities of wheat and other cereals which supply a considerable portion of our own continent. The junction of the waters of the Adriatic with those of the Archipelago would effect a saving in time of two days in the voyage from the harbors of Brindisi, Ancona, and Trieste, to the Levant. It would also greatly facilitate the establishment of local traffic, and probably lead to the adoption of a regular system of steam communication of which Greece is very much in want. At present the coast is not particularly well furnished with harbors, but those that do exist are capable of both improvement and extension. Moreover there is every inducement to construct new ones, as the adjoining bays are deep and afford a secure anchorage for vessels of heavy tonnage.

The present project is a revival of a similar one entertained in the days of the Roman emperor, Nero; and considering that the obstacles in the way of its accomplishment are comparatively few and insignificant, it is somewhat astonishing that the enterprise has never been carried out. Probably the miserable state of decadence and abject inferiority into which the country fell, totally debarred all such attempts. The extreme points of the Isthmus of Corinth are Heapolis and Kalamakis, and supposing them, like Suez and Port Said, to represent the respective mouths of the intended canal, its length would not exceed three miles at most—a very insignificant cutting, so far as the actual lineal dimensions are concerned. It was anticipated, and experience has now demonstrated, that the nature of the material through which the Suez Canal is excavated, will constitute the principal and possibly the sole difficulty to be contended with in future. As it is, the reduction of the present batter of the side slopes is imperative. If not performed by excavation, the operation will proceed spontaneously by the gradual sliding of the sand into the water, whence it will be removed by the dredgers, which, under any circumstances, will have a busy time of it for some years to come. Fortunately, this difficulty does not exist in the projected canal in the Morea. The earth is of a tenacious character, which will offer a better resistance to the disintegrating action of the water agitated by the passage of ships and the motion of screws and paddles, and thus reduce the cost of maintenance and repair. It has been estimated that this important work can be carried out at the moderate cost of half a million. Without taking into account the number of contingent steam and sailing ships which would avail themselves of the passage *via* the Corinth Canal, there would be a regular traffic of the boats of the Messageries Impériales, of the Company of Marseilles, of those of the Austrian Lloyd's, and of those belonging to the Italian service. The total of these would be quite a sufficient guarantee for the investment of the capital required. Were the work once executed, Kalamakis, which at present is but a village, would speedily become a maritime town of importance, and numerous cities, long since abandoned, and, as it were, buried, would be disinterred, restored to life, and ultimately constitute commercial centres from which to export the mineral wealth with which the country abounds. The welfare and prosperity of every nation are in direct proportion to the means it possesses for facilitating its internal and external commerce. No people are in greater want

of these means than the Greeks, and the wisdom of the attempt to obtain them by a ship canal in the first instance, will be apparent to every one who is acquainted with the physical character of the country, and the many obstacles they present to the introduction of railways and even of common roads.

HIGH CLASS STEAM ENGINES.

From "Engineering."

We were greatly amused a few days ago at seeing, in the columns of a contemporary, "the most economical engines, so called, because they burn little coal," defined as those with "a multiplication of moving parts, often accompanied by bad design, bearing surfaces deficient in area, and a general lack of strength in the parts, and of fitness to the intended purpose." There was a freshness and originality about this definition which took our fancy mightily, and we have quoted it here because it serves to describe—as clearly as words can describe—just what we consider a "high class" steam-engine ought *not* to be. We should ourselves rate as of a high class, an engine provided with all the appliances necessary to true economy, having all its details well proportioned, and having no part which did not serve some useful purpose. It is as great a mistake to suppose that an economical engine must necessarily be complicated as it would be to imagine that an engine which is of complicated construction must therefore be economical. As we pointed out in a recent number, no "improvement" should be applied to an engine unless—under the particular circumstances under which the engine is worked—its employment will effect a clear annual saving more than sufficient to pay a proper interest on the extra capital sunk in its first cost; and the true economical value of any "improvement" will be represented by the excess of the annual saving it effects above this interest—any extra cost of maintenance being, of course, duly allowed for. The higher the price of fuel at the place where the engine is worked, and the greater the number of hours per annum during which the engine is kept running, the greater, also, will be the expenditure which it will be justifiable to make on "refinements," as they are called by some engineers; and those who have gone into the question carefully, well know that the occasions are very rare where these "refinements" can be neglected without wasteful results ensuing.

Notwithstanding these facts, well known as they are to competent men, there is a certain class of individuals to whom most "refinements" are abominations. They will permit the use of a steam jacket, perhaps—probably because when once the engine is erected, this jacket is out of sight, and consequently, according to the old proverb, out of mind—but any refinement that necessitates a moving part, is a terror to them. A bar of iron or steel—no, we beg pardon, not steel; steel to these people is as as yet a new and untried material—may, according to these "engineers," be employed as an ordinary slide-valve spindle, and may move backwards and forwards for years without risk of failure; but attach it to an expansion valve, and—woe to the unhappy mill-owner!—it may break any minute, and great and disastrous will be the loss incurred by the consequent delay. Really, when we think of all this, we are almost lost in admiration at the unrecorded heroism of the hundreds of factory proprietors and steamship owners who have for many years past actually used engines with expansion valves, notwithstanding the awful consequences the latter involve. Our admiration, however, is diminished when we remember that these people are infatuated, and that they actually believe that by using engines of a high class, and thereby effecting a considerable annual monetary saving, they are doing rather a good thing for themselves than otherwise. The "anti-refinement" engineers, whose opinions we have expressed, however, know better than this. They feel assured that the crash will come sometime, and that then they will be glorified.

It is melancholy to consider how few of these "anti-refinement" gentlemen have a chance of being thus glorified during their lifetime. Hundreds of engines, such as they condemn, go on working day after

day and year after year, with most provoking regularity; and although failures *do* take place, yet they are but few and far between, and certainly the percentage of such breakdowns is not greater than—if indeed it is as great as—it is with engines of the very plainest construction. Judging from these facts, we are led to believe that the "anti-refinement" class of engineers must be blessed with Zadkiel-like powers, and that their utterances refer not to things of the present, but to things to come. If this supposition be correct, and *if* their prophetic powers are also of a reliable character, then their sons, or grandsons, or great-grandsons, or great-great-grandsons, may be gratified by beholding the disasters that their forefathers had foretold—always supposing that the said forefathers and their predictions had not been totally forgotten in the meantime. This is a serious matter, but as men don't believe much in prophetic powers nowadays, we fear that the present generation will go on using economical engines, and that the certainty of present profit will have more influence with them than the doubtful possibility of future calamities. Inasmuch, however, as there may be some users of steam power who, having a strong affection for posterity, may wish to benefit (?) future generations by following the precepts of the "anti-refinement" clique, we have compiled to the best of our ability a few axioms which embody those precepts, and which may be of use to those wishing to adopt them. These axioms are as follows:

1. It is very wrong—we had almost written wicked—to use *any* moving parts in a steam-engine. But inasmuch as you must use *some*, use as few as you can, and never mind if you could get more economical results by using a greater number.

2. It is very wrong to build double-cylinder engines. Such engines have "two or three sets of slide and expansion valves;" and although in so many instances they have apparently given such good results, this is merely a deception, and is more than counterbalanced by their great internal friction.

3. Cornish engines are "excessively simple." [In order that the reader may appreciate this axiom thoroughly, he is recommended to study working drawings of a set of "Cornish" valve gear, including the cataract, and he will thus learn how an "excessively simple" engine may be made.]

4. Engines using 22 lbs. of steam per indicated horse power per hour are "huge scientific toys," the size of the engine not affecting this statement. It is wrong for grown-up people to play with toys; therefore such engines should not be built. The fact that they do their work well and economically is of no consequence.

5. The fact of economical engines requiring less boiler power is not to be taken into consideration in estimating the relative first cost, or cost of maintenance, of "high class" and ordinary engines.

6. "When an engine has but 10 or 12 hours to work out of the 24, when it is lightly loaded, when it is placed in the hands of first-rate attendants, and when coal is very dear, the introduction of a great deal of complication may be permissible." Taking the "excessively simple" Cornish engine as a groundwork, a complicated engine may be easily designed to suit the above circumstances.

We could, if our space permitted, give many more such axioms, but we must refrain, as, before concluding this notice, there are two matters, both relating to the double-cylinder engine, of which we desire to say a few words. These matters are: first, the idea which exists, even in the minds of many engineers who ought to know better, that the internal friction of a double-cylinder engine is greatly in excess of a single-cylinder engine of equal power, and equally good construction; and, secondly, the idea which is also prevalent with some people, that the "duty" of a double-cylinder engine is more likely to fall off as wear of the parts takes place, than is the case with a single-cylinder engine. Now we are of course perfectly aware that in the double-cylinder engine a certain amount of extra friction is caused by the use of an additional piston, and of two or perhaps three additional stuffing boxes; but in reality this extra friction forms an insignificant portion of the whole internal friction of the engine, even when the latter is running light. When the engine is working with a load, the percentage of extra friction due to the extra piston and stuffing boxes is still further diminished, for of course the friction of these parts is not increased by the load itself as is that of the crosshead guides,

crank shaft bearings, etc. Against the extra friction just mentioned must be set—supposing balanced valves not to be used—the diminished friction of the slide valves in the compound engine. The friction of a slide valve is due, first to the difference between the pressure in the valve chest and that in the exhaust cavity; and second—during a portion of the stroke—to the difference between the pressure in the valve chest, and that in that end of the cylinder in which the steam is expanding, this difference of course acting on the area of the port covered by the valve. If now the two slide valves of a double-cylinder engine were each of the same size as that of a single-cylinder engine, the total friction due to the first of the above-mentioned causes would be the same in both cases, the only difference being that in the double-cylinder engine the total difference of pressure would be divided between two valves instead of acting upon one alone. In reality, however, the two valves of a compound engine are not each of the same size as that of a single engine of equal power, one being smaller, and hence there is a saving of friction. Again, in the compound engine the cut-off of the steam of course takes place much later than in a single-cylinder engine working with the same degree of expansion, and hence the unbalanced pressure on the valves due to the second of the above-mentioned causes is less, and the friction is consequently less also.

Next as to the deterioration of "duty" caused by wear and tear. And here we may state that there is no excuse for leaky joints in either single-cylinder or compound engines. Pistons and valves, however, will leak sometimes; but in these cases compound engines have a decided advantage on account of the less effective pressure to which their parts are subjected. Thus in the case of the valve and piston of the high pressure cylinder, the pressure causing leakage is only equal to the difference between the boiler pressure and that at which the steam is discharged into the low pressure cylinder, while in the case of the valve and piston of the latter the maximum "leakage pressure," as we may call it, is equal to the difference between that at which the steam is received from the high pressure cylinder and that existing in the condenser. The weight of steam that would be allowed to pass to waste into the condenser by a given amount of wear in the pistons or valves, is therefore much less in the case of a compound than in that of a single cylinder engine, and this fact goes far to explain the excellent duty which the former engines undoubtedly do give even when considerably out of order.

The Prussian Government has military maps of every foot of its territory so complete that every hill, ravine, brooklet, field, and forest is delineated with perfect accuracy It is a common boast of Prussian military men that within the space of eight days 848,000 men can be concentrated to the defence of any single point within the kingdom, and every man will be a trained and well-equipped soldier.

Fairlie Engine.—A double bogie eight-wheeled 24-ton Farlie engine, built for the Nasjo and Oscarsham Railway in Sweden, was tried on Monday on the Ring Railway of the Fairlie Engine and Steam Carriage Company at Hatcham, in the presence of the Duke of Sutherland and about forty gentlemen and practical engineers. The engine was run round the curves of 50 ft. radius, at the speed of 20 miles an hour.—*Engineer.*

Blast Furnaces.—It is estimated that in England 500 blast furnaces are reducing by their intense heat nearly 12,000,000 tons of iron ore to 4,800,000 tons of metallic iron, which, at its place of production, has a value of about £11,000,000 sterling. Those blast furnaces consume more than 14,000,000 tons of coal; and, to convert the pig-iron obtained into bars, rails, etc., a like quantity of coal is required. In France the great iron industry is no less active. The works of Messrs. Schneider and Co., at Creusot, the largest in France, have 50 acres under cover. Here are 15 blast furnaces, with 27 steam-engines blowing air for them, and forging iron besides. At the mines and works over 3,500 men are employed. In Belgium, at the works of the Company Cockerill, near Liége, 7,400 work-people are employed.

THE PROPERTIES OF MALLEABLE CAST-IRON.

By DR. ADOLPH OTT.

From the "Journal of Applied Chemistry."

The increased flexibility of malleable iron, according to Mr. R. Mallet, is to be attributed to the fact that small crystalline scales of graphite are uniformly disseminated through the mass of the iron. Indeed, it is otherwise known that the most rigid materials become flexible when fibrous or scaly crystals of different natures are distributed through them; these latter may themselves form inflexible bodies when united to larger masses. The flexible Indian sandstone, for instance, consists of a mass of quartz crystals through which fibres of asbestos are uniformly disseminated; other kinds of flexible sandstones contain mica crystals in the quartz mass, as, for instance, the itacolumite, which, in Brazil, is regularly associated with the diamond. The flexibility of the respective bodies must in all these cases be ascribed to the property of the smooth crystals to change their relative position to each other, and with regard to the mica scales in the sandstone, they behave like the graphite scales in the iron.

According to Pelouze and Fremy the specific gravity of malleable iron approaches very nearly that of cast-iron. Brull, as the result of three determinations, found the numbers 7.10, 7.25, and 6.35. The specific gravity of wrought iron being from 7.6 to 7.8, we have another proof that malleable cast-iron is not identical with wrought iron. The fracture of malleable cast-iron is very different from that of any kind of wrought iron; it is darker and less brilliant, and lacks that fibrous aspect so characteristic of tough wrought iron. It is similar to dark and ordinary pottery, but different from it in color and lustre. In forging, the aspect of the fracture becomes greatly altered, on account of the flexibility of the material, which sometimes requires considerable hammering before it breaks. The fracture of very carefully manufactured malleable iron appears, on the average, more like that of a very fine grained, white cast-iron than that of wrought iron. In large pieces the fracture is uniform throughout. In filing, turning, and planing it works quite similar to wrought iron, but the surface often appears somewhat whiter. Large pieces can seldom be well turned to a great depth. According to some statements, malleable iron is capable of taking a better polish than cast-iron, and it takes as good a one as cast steel. It also holds a better lustre than many sorts of dark and impure wrought iron, but the polish is inferior to that of good steel, as in razors of first quality, even the surface appears a little whiter. Good hard cast-iron may probably be polished as well. With regard to the hardness, reliable data are not procurable. Malleable cast-iron is generally very soft—softer than wrought iron of any kind. It takes the impression of the hammer with a very slight blow, and wears off rapidly in contact with rough surfaces.

It is exceedingly porous, as may be expected from its small density. According to Brull, oil, when left in a cup of malleable iron, penetrates through it in a very short time; the correctness of this assertion, however, remains doubtful. Cast-iron bells are far more elastic than bells of malleable iron, producing also a higher and clearer sound.

Morin and Tresca have found that the elasticity of malleable cast-iron is considerably less than that of the most inferior wrought iron. The absolute power of resistance is indicated by the latter as being 35 kilogrammes per square metre. Thin pieces, of a diameter not over one-quarter or three-eighths of an inch, may be bent while cold, without cracking; but they can rarely be restored to their original state without being partly or altogether fractured. However, the end of a rod may be forged till red hot, without a break or crack being produced; thin plates may safely be hammered into hollows, provided they are not too deep. Malleable iron will bear rolling to a small degree. All these manipulations bring about a closer grain, and a fracture similar to that of fine grained steel-like iron. No instance is known where malleable iron has been drawn into wire; but this is possible, since it will bear a slight elongation, assuming thereby a finer grain. It may be pretty well forged at a low red heat, somewhat above a cherry red heat, but in endeavor-

ing to beat it out, it tears and breaks to pieces. According to Mallet, this temperature, and that beneath a bright yellow heat, are those at which it may be best forged; but it is more than probable that various kinds act differently under the same circumstances. This peculiarity certainly deserves further attention, on account of the fact that various articles which have not, as yet, been produced from malleable iron, might advantageously be made from it in cases where the form of the cast piece might have to be altered afterward. When hammered at yellow heat, malleable iron falls to pieces, and large, not uniformly cemented pieces, appear in the interior.

It is clear that malleable iron can not be welded properly; indeed, this is the case even if two pieces can be made to stick together, and the surface of contact be kept free from rust; it is self-evident that it can not be welded with wrought iron or steel, still it may be soldered with them by means of a hard solder. With respect to the fusing point of this metal, it is a high one; it lies above that of gray or halved cast-iron, but probably not above that of many sorts of white or hard cast-iron, and certainly considerably below that of cast steel. In the fire, malleable cast-iron is said to become more slowly oxidized than ordinary cast-iron. In France, the silver refiners use a large number of crucibles that are manufactured from that material, but no accounts exist of how much iron they leave to the silver. According to Brull, malleable iron can be tempered with the ordinary carboniferous cementing powders, as well as with prussiate of potassa. If watered when bright red hot, it may be tempered more or less; still the temper is always imperfect, not uniform, and quite different from that of good steel, but perhaps more perfect than that which wrought iron assumes, when suddenly cooled. Still, correct statements are yet wanting with regard to this point.

NOTES ON THE GREAT PYRAMID OF EGYPT.

From a recent pamphlet* by Col. Sir Henry James, of the British Ordnance Survey, we extract the following notes:

Herodotus, writing about the year 450 B. C., tells us that the Egyptian cubit is equal to that of Samos, that is to the Greek cubit.

In the Hecatompedon of the Parthenon at Athens (so called because the platform on which the columns stand was made a double square of exactly 100 ft.) we have preserved the length of 100 Greek feet at the time this temple was built, about 440 B. C.

From the measurements made by Mr. Penrove at the Parthenon in 1846, we have the length of the Greek cubit equal to 18.2405 in., and if the assertion of Herodotus be correct, this must have been also the length of the Egyptian cubit at the time he wrote, about 2,320 years ago.

We shall presently see that this was also the precise length of the Egyptian cubit at the time the Great Pyramid was built, about 4,000 years ago.

Sir Isaac Newton, in his celebrated "Dissertation on Cubits," says: "It is very probable that at first the measure of it (the Great Pyramid) was determined by some round number of Egyptian cubits."

From a measurement by Mr. Inglis, who first measured all four sides of the base, a mean length was obtained of 9,110 in.

The length similarly obtained by the Ordnance Surveyors was 9,130 in. A mean of the two results is 9,120 in., and it is remarkable that one of the measures of Mr. Inglis is exactly 9,120 in., and of one of the Ordnance Surveyors 9,121 in.

We may, therefore, regard 9,120 in., or 760 ft., as the true length of the side of the Pyramid. But this is precisely 500 Egyptian or Greek cubits of 18.2405 in.

This verifies the conjecture of Sir Isaac Newton that the base was made a round number of Egyptian cubits.

King Cheops, having decided that the base of his Pyramid should be 500 cubits square, decided also that the rise at its corners should be 9 in height to 10 in horizontal length.

The length of the side of the square base being 760 ft., half of the diagonal is equal to 537.4 ft., nine-tenths of which is the

* Notes on the Great Pyramid and the cubits used in its design. By Col. Sir Henry James, Director-General of the Ordnance Survey. Southampton: Thomas Gutch & Co., 1869.

height, 483.66 feet; which agrees very closely with several previous determinations.

The angle of the corner, therefore, was about 41 deg. 59 min., which corresponds very closely with measurement. The angle of the slope of side would accordingly be 51 deg. 51 min. Col. Vyse, from actual measurement of the casing stones, found the angle to be between 51 deg. 50 min. and 51 deg. 52 min.

A square pyramid having a rise of 9 in 10 at its angles, has also this remarkable proportion: its height is to the periphery of its base as the radius to the circumference of a circle, very nearly.

In his "Dissertation on Cubits," Sir Isaac Newton says: "In the middle of the Pyramid was a chamber most exquisitely formed of polished marble, containing a monument of the king. The length of this chamber, according to the measure of Greaves, was 34,38 ft., the breadth 17.19 ft.; that is, it was 20 cubits long and 10 cubits broad, the cubit being supposed to be 1.719 English ft."

The cubit thus derived was, therefore, 20.628 in. in length, and called by Newton the cubit of Memphis.

He goes on to say: "Those who shall hereafter examine the Pyramid, by measuring and comparing together with greater accuracy mere dimensions of the stones in it, will be able to determine with great exactness the true measure of the cubit of Memphis, and from thence the sacred cubit."

The cubit of Karnak, in the British Museum, measured carefully by the author, was found to be 41.398 inches in length. It is divided into 14 palms, and the palms into 4 digits. This is, therefore, a double or royal cubit of Memphis, the single cubit being 20.699 in. in length, and differing only .071 in. from that deduced by Newton from the measure of the King's chamber.

Again, Newton says in his "Dissertation on Cubits:" "I am inclined to think that the cubit of Memphis, at the time when the Jews went down into Egypt, was equal to 5 palms of the Chaldæo-Hebraic cubit, and that the Jews thus determined the magnitude of that cubit by 5 palms of the proper cubit."

This would make the Chaldæo-Hebraic cubit one-fifth longer than the cubit of Memphis, or equal to $20.699+4.14=24.84$ inches.

A cubit found by Mersennus measured 24.83 inches, and this is the length of the sacred Hebrew cubit given by Newton as the final result of his investigations.

This was probably divided into 6 palms of 4.14 in. each, and 10 of them making the royal cubit of Memphis.

This cubit is the breadth of the entrance passage to the Pyramid, and the King's chamber is 10 such cubits in length by 5 in breadth.

The cubits upon the Nilometers at Cairo and at Elephantine are equal to the cubit of Memphis, but are divided into 6 palms.

The cubit length of 20.699 inches was divided in three different ways.

On the sacred cubit it was divided into 5 palms; on the Nilometer into 6 palms, and on the cubit of Memphis into 7 palms.

The angles of inclination of the descending entrance passage to the Pyramid, and of the ascending passage to the King's chamber, are the same, and skilfully designed by the architect to be a little under the "angle of rest or quiescence," or a little over 26 deg.

At this angle anything could be made to slide down with ease.

The adjustment of the two slopes admits of the use of counterpoised trucks, by means of which any one could be easily transported from the entrance of the Pyramid to the grand gallery within.

THE LINE TO SALT LAKE CITY.—On the 10th January, the completion of the line which connects Salt Lake City with the Pacific Railroad, and thus brings the capital of Mormondom into railway communication with all the great cities of the Union, was celebrated at Salt Lake. The line is 37 miles in length, its northern terminus being at Ogden, the junction of the Union Pacific and Central Pacific roads, and it is unique in the history of railways in this, that it has been built from first to last without money. The iron and rolling stock were supplied by the Union and Pacific Company in payment for work done in the construction of that line; the contracts for the making of the road were taken in return for shares in its stock. Fifteen thousand Mormons, it is estimated, attended the celebration of the completion of the line.

RUSSIAN ORDNANCE EXPERIMENTS.

From "Engineering."

We print the following particulars, translated from the "Russian Artillery Journal," of the trial of an 11 in. Krupp's cast-steel breech-loading gun, fired against the Hercules' shield last August, at the Wolkow Artillery Ground, near St. Petersburg.

Up to the year 1868, the regulation calibres of our breech-loading guns for coast defence were 8 in. and 9 in.

Trials made in Russia, and the comparative trial with guns of large calibre in Prussia, agreed in demonstrating that the 8 in. coast gun acts with great effect on ships with 4½ in. armor plating, even at distances of 1,866 yards, and that at the same distance the 9 in. gun can do very serious damage to ships with 6 in. armor plating. At a distance of 700 yards the 9 in. gun pierces an armored shield with 8 in. plates. For success in attacking ships with 8 in. or 9 in. plates at great distances, or ships with still thicker plates even at short distances, the 9 in. gun is not of sufficient power. Having regard to this, we have included the 11 in. gun in the regulation calibres for coast defence.

The first trial gun of this calibre, made of cast-steel and strengthened with hoops, was manufactured for our Government at Krupp's factory. This gun differed somewhat in its measurements from the design to which the new 11 in. guns are made. This difference, which arose from the gun having been originally intended for a muzzle-loader, consisted principally in the length of the bore, being 27 in. shorter than the length of the bore of the 11 in. gun, according to the design finally adopted. In consequence of this, the initial velocity of projectiles fired with battering charges from the trial gun would necessarily be about 50 ft. less than from the new guns. The trial gun had been submitted last year at Krupp's factory to a trial of endurance, had fired 400 rounds with battering charges, and had then been removed to the Wolkow Artillery Ground, near St. Petersburg, to ascertain its destructive effect against armored shields of very great strength.

The experimental firing took place in the month of August of the current year, against a shield representing a portion of the broadside of the iron-clad English ship Hercules. This shield was built up in the following manner: Three wrought-iron plates, each 16 ft. long, 3 ft. 8 in. broad, the two lower 9 in., the upper one 6 in. thick, were fastened by bolts with countersunk heads to a backing consisting of horizontal teak balks, 12 in. thick, between which, through their whole thickness, seven 1 in. strips of iron plate were inserted, strengthened with angle iron.

Immediately behind the teak balks were two wrought-iron plates, one behind the other, each 1 in. thick. Behind these came a row of vertical oak balks, 9 in. thick, between which, through their whole breadth, were inserted nine 1 in. strips of iron plate, strengthened with angle iron. The whole rested against two rows of horizontal oak balks, the front row being 6 in. thick, and the hinder 9 in. Behind the latter was fastened a 1 in. wrought-iron plate. The whole thickness of the backing was, therefore, 39 in.; the whole thickness of the part of the shield with 9 in. plate, 48 in., and the whole thickness of the part of the shield with 6 in. plate, 45 in. The whole length of the shield was 16 ft., its height 11 ft. At the back of the shield five wrought-iron 1 in. stays were riveted on, and rested on 14 in. timbers, which were connected together, and formed a frame to support the shield. All three plates were made at the Millwall Works, London. The Hercules shield is one of the very strongest armored shields designed up to the present time.

In June and December, 1865, at Shoeburyness, gunnery experiments with the Armstrong 300-pounder (10.5 in.), and 600-pounder (12 in. and 13 in.) were made against a similar shield. The solid steel projectiles, fired from the 300-pounder, with 50 lbs., 60 lbs., and 66 lbs. of powder, did not pierce the shield, even at the shortest distances. The 600 lbs. solid steel projectiles, fired with a charge of 100 lbs., at a distance of 700 yards with an initial velocity of 1,420* ft. per second, went through the plate, and remained in

* This statement cannot be correct. The English report gives 1,276.27 ft. for a final velocity for a steel shot weighing 600 lbs. The velocity, 1,420 ft., was at 60 ft. from muzzle of gun.

the wood backing when they struck undamaged portions of the shield; on the other hand, when they struck places in the shield which were already weakened by previous rounds, they went right through the target. From the results of the trials at Shoeburyness, it appeared that the Hercules' shield is of very great resisting power, and that the capabilities of the 600-pounder Armstrong gun against it, even at small distances, were insufficient.

The firing performed here from the 11 in. cast-steel breech-loading gun, took place at a distance of 466.6 yards, with cast-steel shells, with *thin* lead jackets, which were made at Krupp's works, and brought up to the weight of 550 lbs. by filling the hollow with sand and filings. Five rounds were fired from the gun, one with battering charge, *i. e.*, with 91.5 lbs. of prismatic powder, and four with diminished charges, for the purpose of determining their destructive effect upon the target at different distances, without rendering it necessary to move the heavy gun to other distances. To this end two rounds were fired with a charge of 85.5 lbs. of prismatic powder, and two rounds with 72 lbs. of the same powder. With the charge of 85.5 lbs., the trial gun produces the same effect at 466.6 yards as with the battering charge at 746.6 yards, and as the new 11-in. gun with battering charges at a distance of 1,108.3 yards. With a 72-lbs. charge the effect of the trial gun is the same at 466 yards as at a distance of 1,610 yards with the battering charge, and the same as that of the new 11-in. gun at a distance of 1,960 yards. The effect of the 11-in. trial gun with battering charge at 466.6 yards is the same as that of the new 11-in. gun at 842 yards.

The principal damage done to the shield during this gunnery trial was as follows: The first shot fired with a battering charge of 91.5 lbs. of prismatic powder struck the lower 9-in. plate in about the middle of it, near the upper edge, went through the whole target and continued its flight into the plain. The hole produced in the plate was of an oval form, having a horizontal diameter of 11 in., and a vertical diameter of 13 in. By this shot a bolt was broken, carrying away a stay from the backing. The projectile, which was picked up after the firing, proved to be quite whole; the lead jacket was stripped off; the length of the shot was lessened by $\frac{1}{4}$ in.; but in other respects its dimensions had apparently remained unaltered. At the second round, which was fired with a charge of 85.5 lbs. prismatic powder, the projectile did not strike the shield direct, but grazed 16.3 ft. before it, hitting a plate lying on the ground, and then struck with its side against the lower 9-in. plate of the shield. The indentation produced was about $2\frac{1}{2}$ ft. long, up to 1 ft. broad, and up to $4\frac{1}{2}$ in. deep. The plate was buckled inwards 2 in., and showed cracks on the bottom edge of the hole made by the first shot. The projectile broke in pieces.

At the third round, which was fired with 85.5 lbs. of prismatic powder, the projectile struck the joint between the two lower plates, pierced the whole shield, grazing 58 ft. 3 in. behind, and then continued its flight. The dimensions of the hole made by this shot were almost the same as in the case of the first. By this shot a bolt was also broken and a stay carried away; the shot, which was picked up after the trial, proved to be broken into two equal parts, about perpendicular to its axis.

At the fourth round, which was fired with a charge of 72 lbs. prismatic powder, the shot struck the upper 6-in. plate near the lower edge, grazing the top edge of the middle plate, and went right through the shield. The oval hole made by this shot was of somewhat larger dimensions than the previous ones, the horizontal diameter being about 13.5 in., and the vertical 11.9 in.

Of broken bolts there were 3—2 in the top plate and 1 in the middle plate; in addition, a stay was separated from the backing. The shot, which was picked up after the firing, proved to be quite whole; the lead jacket was stripped off; its length was diminished by almost $\frac{3}{10}$ in., otherwise its dimensions had apparently remained unchanged.

At the 5th round, which was fired with a charge of 72 lbs. prismatic powder, the shot struck the middle 9-in. plate near the lower edge, penetrated so far into the target that the surface of the end of the shot was level with the front surface of the plate, and there remained. In doing this the head of the shot went through the plate the whole thickness of the teak backing, the two 1 in. plates, behind the teak timbers, and about 4 in. into the upright oak balks. The other damage visible

after this shot consisted in injury to the stay, which was in the neighborhood of the point of impact, and in carrying away some rivets. The shot remained apparently whole.

After the termination of the trial, the whole shield had been driven back 6 in., almost parallel to its original position.

This gunnery trial, in which the plates of the shield had proved to be very good, showed that our 11 in. gun of the new construction, when fired with good steel projectiles with a thin lead jacket, is capable of doing the following damage to armor-plated walls of the strength of the broadside of the British ship Hercules.

1. At a distance of about 842 yards this shield, both with 6 in. and 9 in. plates of good quality, is pierced with a considerable surplus of power.

2. At a distance of about 1,166 yards this shield is also pierced, although with but a small surplus of power.

3. At a distance of about 1,983 yards a shield of the strength described, with 6 in. plates, is pierced.

4. At the same distance, when fired against the shield protected by 9 in. plates, the shot pierces the plate, and sticks fast in the backing, after it has penetrated its whole length. From the results of this xperiment, it may be concluded that our 1 in. rifled *cast-steel* breech-loading gun of the new make, provided with good *steel* projectiles, is considerably superior in execution to the English 12 and 13 in. (600-pounder) wrought-iron rifled 25-ton muzzle-loading guns; and that it is a very efficient gun against fleets with armor plating of considerable thickness, not only at short and medium, but even at greater distances.

If we consider that, as shown by the experiment made, when fired against the Hercules' shield, at a distance of about 1,983 yards, the projectiles of the 11 in. gun penetrate their whole length, and, at a shorter distance of about 1,166 yards, go through the whole shield, and avail ourselves of the formulas derived from the results of the gunnery experiments of the English, Prussian, and other artilleries, against armor plates with backing, we gather that the distance of 1,399 may be regarded as the limit at which our 11 in. guns, of new make, may produce very destructive effects when fired against ships whose broadsides are of the strength of the Hercules and are covered with 9 in. plates.

Although at this distance we cannot reckon upon every shot fired piercing the broadside described, still it is beyond a doubt that they would stick fast in the wood backing, after having gone through the 9 in. plate, and there produce the full effect of their bursting charge.

At a distance of about 1,282 yards all good 11 in. steel projectiles must pierce a shield of the strength of the Hercules' broadside, protected by wrought-iron plates of the best quality."

THE RESISTANCE OF VESSELS.

(*Continued from page* 288.)

ROLLING OF SHIPS.

Stability and Free Oscillation.

The statical stability of a ship in still water depends upon two equations and an inequality.

Its weight must equal that of the fluid it displaces, or it will adjust itself by changing its water-line. This involves a first equation.

The centre of gravity of the displaced water must be in the same vertical line with the centre of weights, or there will be a couple which will produce rotation; after which the ship will take up a fresh position. This involves a second equation.

In case of a small angular displacement, the centre of gravity of the displaced water (or centre of buoyancy) must move out faster than the centre of weights; otherwise, on the slightest derangement, there will be an upsetting couple; that is to say, the equilibrium is unstable. This involves an inequality.

The arm of the couple is the horizontal distance between the centres of weight and buoyancy. The moment of the couple is the product of this into the weight, or, what is the same thing, the displacement of the ship. If the centre of buoyancy moves out faster than the centre of weight as the ship heels, there is a right-

ing couple; if not, there is an upsetting couple, which tends to bring the ship to some new position of equilibrium.

If we consider a vessel having a plane of symmetry, like that in which the masts, stern, stern-post, and keel of ordinary ships lie, and rolling transversely, we gain much in geometrical simplicity, and also in simplicity of language. We are enabled to deal with the mechanical questions by means of plane geometry, and we are still able to extend them when necessary, by the ordinary rules of the composition of motion. For this purpose, we have only to consider the axis of motion as parallel to the plane of symmetry and to the water section. The statical stability, as already remarked, is measured by the weight and by the horizontal distance between the centres of weight and buoyancy. But when these coincide in horizontal position, as they do when there is equilibrium, we are driven to some other measure in order to avoid indeterminateness at the limit. For this purpose we avail ourselves of the point at which the vertical line through the centre of buoyancy strikes the plane of symmetry, or *middle line plane*, as it is technically called. The limiting position of this intersection, when the angular deviation is indefinitely small, is called the metacentre. This metacentre is the critical point below which, if the centre of weight be kept, there will be stable equilibrium.

It is shown in books on hydrostatics that if a floating body receive a *small* inclination, the two water sections intersect in a line passing through the centre of gravity of each, and also that the line, passing through two successive centres of buoyancy, tends to parallelism with the water section. It follows that the stability of a ship, statically considered, may be measured by the statical stability of a solid whose centre of gravity coincides with that of the ship, but whose surface, instead of floating in water, rests on a horizontal table. This representative surface is the surface formed by the centres of buoyancy of the ship at different inclinations. The metacentre of the ship is then the centre of greatest or of least curvature of this representative surface, called the *surface of buoyancy*, according to whether we consider transverse rolling or longitudinal pitching.

When we pass from statics to dynamics, the righting or upsetting force simply represents an acceleration. But if the ship be considered as concentrated at its centre of gravity (in disregard of the actual distribution of weights in respect of inertia), the same geometrical considerations hold, and the space through which the centre of gravity rises or falls, as the surface of buoyancy rolls, is called the measure of *dynamical stability*.* It is simply proportional to the integral of the statical stability taken with reference to the angle of inclination. Its product into the displacement gives the *mechanical work* required to heel the ship, considered as concentrated at its centre of gravity, to a given angle. An example of its use is in the solution of the problem of finding how much a ship would lie over to a sudden gust, strong enough, if it came on gradually, to heel the ship to a given angle. The rough solution is, that she would lie over to double the angle of the statical stability, and this remark is of importance in judging of the safe limits of a ship's stability. This solution, it is to be observed, takes no account of the moment of inertia of the ship about its centre of gravity, and very little account of external form.

Experiment and theory both go to prove that the time in which a ship performs a complete double oscillation varies very little, whether the amplitude of the oscillation be small or large. Hence every ship has its equivalent pendulum. If k be the radius of gyration of the ship, μ the distance between the metacentre and the centre of gravity, the length of the equivalent pendulum is $\frac{k^2}{\mu}$; the periodic time† is $2\frac{\pi k}{\sqrt{g\mu}}$, and the greatest angular velocity is $\frac{2\sqrt{g\mu}}{k}\sin\frac{1}{2}\theta$, where θ is the amplitude, or departure from the vertical; but the approximation in this last formula is much less than in that for the time.

Dupin has shown that the free rolling of a ship, regarded without reference to

* The true dynamical stability is the actual work done in heeling. But the words are ordinarily used in the sense stated in the text.

† The time here used is that of a double oscillation; *i.e*, the time which elapses between the bob of the pendulum passing the lowest point twice in the same direction. There is very often confusion between double and single oscillations, both with analysts and in the records of experiments.

the disturbance or resistance of the water, is analogous to the free rolling and sliding on a smooth plane of the surface, which is the envelope of its planes of flotation; the centre of gravity, the upward pressure of the fluid, and the moment of inertia being supposed to remain unaltered. But, although this statement reads simply enough, the expression for the time and the period, which result from it, are exceedingly complex. An investigation of it, subject to the sole restriction that the transverse section of the surface enveloping the planes of flotation shall be circular, has been given by Canon Moseley, in the "Philosophical Transactions" for 1850, p. 626, and is reprinted in his "Engineering and Architecture." The resulting expression depends upon a hyper-elliptic integral. But we are without evidence as to how far the restriction is fulfilled by ordinary ships; and we do not find reason for supposing that the variation of the radius of curvature, which is thus taken as constant, has ever been practically investigated. There is, however, no difficulty in extending the formula to the general case; but it does not appear that the integration can be effected without introducing restrictions. At any rate the value of the integral has not yet been traced, except for small oscillations, when it reduces to the one previously given. There is a reduction in some particular cases,* and notably in the case of isochronous ships. Professor Rankine* has shown that the condition of isochronism is, that the curve of buoyancy should be the second involute of a circle described about the centre of gravity.

It does not appear that the arithmetical consequences of the variation of the law connecting time and angular velocity in unresisted free rolling have ever been worked out. It would be a very laborious business, and we shall see by and by that it is not the chief problem.

Reverting to the approximate formulæ for small oscillations,

$$\text{periodic time} = 2\,\frac{\pi\,k}{\sqrt{g\,\mu}} = 2\,t, \text{ suppose;}$$

$$\text{greatest angular velocity} = 2\,\frac{\sqrt{g\,\mu}}{k}\sin\tfrac{1}{2}\,\theta,$$

$$= \frac{2}{t}\,\pi\sin\tfrac{1}{2}\,\theta,$$

we see that the periodic time of the oscillation varies directly as the radius of gyration, and inversely as the square root of the metacentre height. This teaches us how to regulate the periodic time of a ship, either in settling her design, or in the distribution of her weights. We see, for instance, that a vessel with a rising floor and flaring sides tends to quick rolling, by having a high metacentre; that a cargo of railway bars has the same effect, by bringing down the centre of gravity; and that running in the guns and sending down the masts has a similar tendency, by decreasing the radius of gyration. The expression for the greatest angular velocity has been sometimes interpreted as indicating that quick rollers roll through

* Let k be the radius of gyration, λ the height of the metacentre above the centre of buoyancy, H_1 and H_2 the *depths* of the centres of gravity and buoyancy, all taken for the upright position. Also let θ be the inclination, and ϑ_1 the extreme, and ρ the *height* of the centre of curvature *above* the actual plane of flotation. The Canon Moseley's formula gives for the periodic time of the double oscillation:

$$\sqrt{\frac{2}{g}}\int_{-\theta_1}^{+\theta_1} d\theta \times \sqrt{\frac{k^2+(H_1+\rho)^2\sin^2\theta}{\{H_1-H_2+\frac{1}{2}\lambda(\cos\theta+\cos\theta_1)\}(\cos\theta-\cos\theta_1)}}$$

It will be observed that $(H_1+\rho)\sin\vartheta$ is nothing but the horizontal distance between the centre of gravity of the ship and that of the plane of flotation; or, in other words, the perpendicular from the centre of gravity on the normal to the flotation envelope. It seems, at the same time, simpler and more general to use this (which we may call ν), instead of considering the curvature. We thus get the periodic time,

$$\sqrt{\frac{2}{g}}\int_{-\theta_1}^{+\theta_1} d\theta \times \sqrt{\frac{k^2+\nu^2}{\{H_1-H_2+\frac{1}{2}\lambda(\cos\theta+\cos\theta_1)\}\{\cos\theta-\cos\theta_1\}}}$$

Now, if ν be constant, that is to say, if the flotation envelope be the involute of a circle described round the centre of gravity of the ship, this reduces to a complete elliptic integral of the first kind; but the solution is not mechanical unless $\nu=0$ or the flotation envelope reduces to a point. When, moreover, the centres of gravity and buoyancy coincide, H_1-H^2 vanishes, and the integral may be at once transformed to its regular expression by writing $\sin\vartheta=\sin\vartheta_1\sin\phi$. We then get for the periodic time,

$$4\,\frac{\sqrt{k^2+\nu^2}}{\sqrt{\lambda\,g}}\int_0^{\frac{1}{2}\pi}\frac{d\,\phi}{\sqrt{1-\sin^2\theta_1\sin^2\phi}}$$

The time at any moment is got by integrating from $-\vartheta_1$ to any value of ϑ instead of to $+\vartheta_1$.—C. W. M.

* See "Transactions of the Institution of Naval Architects," vol. v., for 1864, p. 34. See, also, Froude, "On Isochronism of Oscillation of Ships," vol. iv., for 1863, p. 218.

large angles. The fact appears to be experimentally true, but its inference from this formula involves reasoning in a circle. The formula only shows that for the same amplitude the greatest angular velocity varies inversely as the time; but this tells us nothing about the amplitude, while the formula itself is obtained on the supposition that the amplitude is small.

The position of the ship's centre of gravity, and the length of the radius of gyration, cannot, practically, be obtained by calculation. The centre of gravity is generally found by shifting some known weights through known distances, and observing the angular motion. The displacement and metacentre are of course known by calculation, and the problem is then the same as if the ship were suspended from her metacentre.* The radius of gyration is found by observing the time of a small oscillation in still water, and then eliminating the effect of resistance.†

As the metacentre depends upon the moment of inertia of the plane of flotation, it is different for pitching from what it is for rolling, and so for any intermediate position.‡ Practically, the metacentre for rolling varies from 0 to 20 ft. (as an extreme limit) above the water line, while that for pitching is from 70 to 400 or more feet high. The moment of inertia of the ship also varies greatly with the direction of the axis about which it is taken.

FREE ROLLING IN A RESISTING MEDIUM.

The experiments of Messrs. Fincham and Rawson, undertaken at the suggestion of Canon Moseley§, led to the conclusion that, for vessels of semicircular section, in which the disturbance of the water is the least possible, the dynamical stability, found by experiment, differed very little from that derived from the rise and fall of the centre of gravity; but in the case of a model of triangular section, the stability found by experiment was in defect. In the semicircular model the extreme inclination produced by the sudden application of the force was, with a fair degree of approximation, double that due to its statical effect. With the triangular model the extreme was less than double the statical inclination. This is nothing more than might be expected from the disturbance of the water which would be set up by the angular model, and which would, of course, take up part of the work. But this experimental confirmation of theory is highly satisfactory; and, however we may now look back upon the matter, it is really upon these experiments that the confirmation of our theories rests.

In a resisting medium, the amplitude of the oscillations is very quickly effected, but the periodic time undergoes very slight change. But the period *is* altered to a slight extent. On this subject we refer, firstly, to the account given by Poisson, Stokes, and other writers on mechanics, concerning the oscillation of a pendulum in air; secondly, to Mr. Froude's experiments* on a pendulum oscillating in water, and thirdly, to Professor Rankine's Paper on Keel Resistance,† in which the measure of diminution is given on a certain hypothesis.

Bessel and Poisson have pointed out

* The method, with an account of some experimental determinations on several of H.M.'s ships, will be found in the "Transactions of the Institution of Naval Architects," vol. i., p. 38. See also vol. v., p. 1.; vol. vi., p. 1.; vol. vii., p. 205.

† As to this, see Mr. Rankine's note in the "Transactions of the Institution of Naval Architects," vol. v., pp. 31 and 32.

‡ See Dupin, "Applications de Géométrie." He shows that the metacentric heights for rolling and pitching are, in fact, only the two principal radii of curvature of the surface of centres of buoyancy, and hence the metacentres for intermediate positions may be found by the help of the ellipse of curvature.

§ See "Philosophical Transactions" for 1850, and Moseley's "Engineering and Architecture," pp. 616, 617.

* "Transactions of the Institution of Naval Architects," vol. iii. p. 31. Mr. Froude has there shown that when a pendulum or ship performs isochronous oscillations in a medium, the resistance of which varies as the square of the velocity, the amplitudes of the successive oscillations, as reduced by resistance, will form successive ordinates of a curve, which approaches, with a great degree of exactness, to an equilateral hyperbola, referred to one of its asymptotes; equal periods of the oscillations being represented by successive equal increments of the abscissa. The experiments with a pendulum as exhibited in the diagram (Plate 2, of the volume referred to), accord very closely with the law, which may be thus expressed: If θ_0 be the initial amplitude, and θ_m that at the end of the m^{th} oscillation, then that at the end of any other, say n^{th}, will be

$$\theta_n = \frac{m\,\theta_0\,\theta_m}{(m-n)\,\theta_m + n\,\theta_0}.$$

† "Transactions of the Institution of Naval Architects," vol. v., pp. 30, 31.

that the virtual loss of weight due to oscillation in a resisting medium is greater than that due to the mere immersion. Mr. Moseley makes the same remark with reference to the rolling of ships.

Professor Rankine has investigated the effect of the steadying action of a keel on the rolling in smooth water, on the assumption that the moment of the righting couple is simply proportional to the inclination, and also that the moment of resistance to rolling, caused by the action of the water on the keel and floor, is proportional to the angular velocity. He finds* that the periodic time is altered from

$$\frac{2\pi k}{\sqrt{g\mu}} \text{ to } \frac{2\pi k}{\sqrt{g\mu}\sqrt{1-\frac{gc^2}{4\mu k^2}}}$$

where c is a constant depending on the moment of the resistance, so that

$$c = \frac{\text{moment of resistance of water.}}{\text{displacement} \times \text{angular velocity}'}$$

the effect of the resistance thus lengthening the periodic time in the same proportion as if the inertia of the rolling mass were increased in the ratio of unity to

$$1-\frac{gc^2}{4\mu k^2}$$

and periodic rolling in smooth water becoming impossible when gc^2 is equal to or greater than $4\mu k^2$.

OF EASY AND UNEASY SHIPS.

There is much vagueness in the use of these terms. They are generally applied promiscuously to the practical hindrance caused by motion to the persons engaged in working or manœuvring the ship; to the inconvenience felt by passengers; to the straining of a ship's structure, or the tendency to shift her cargo, or to break away half-fastened weights, like boats or guns.

These all appear to depend in varying proportions on the following exact data:

The extent or amplitude of angular motion.

The rapidity of angular motion.

The acceleration of linear motion.

But the rapidity of linear motion, and the angular acceleration (except so far as this affects bending stress, or as it involves linear acceleration at a distance from the instantaneous axis) do not appear to have much practical influence.

In still water the only motion which is sufficiently great to cause inconvenience is that of rolling. Rolling sometimes produces, as secondary phenomena, both pitching and dipping; but neither of these is sufficient in extent, in still water, to produce inconvenience. The rolling, however, may be considerable, especially in the case of a ship going unsteadily, before the wind. But if the water itself be oscillating, even moderately, or if there be a gusty wind, then a synchronism between any two of the five movements—the wind, the waves, the rolling, the pitching, or the dipping,* or even (to a lesser extent) their concord at regular intervals, may cause them to enhance the effects one or another to such an extent as to become inconvenient, and in certain cases dangerous. In the case of a thoroughly uneasy ship in the most unfavorable circumstances, the axis of angular motion may assume any and every position, and the linear acceleration may take all conceivable directions; but although any particular point may describe the most irregular curves, both in form and speed, relatively to the vessel's course, yet the chief source of practical danger in open water depends upon the accumulation of motion arising from synchronism.

It appears to have been generally observed that vessels which have a short period of rolling, also roll through large angles. In this way the uneasiness of the rolling undergoes a double increase as the period diminishes. Further and more exact experiment is required, before we can say how far it is connected by synchronism with wave motion, or whether it is an independent phenomenon. Our present theories do not show it to be a necessary consequence of rolling in smooth water.

WAVES.

We do not consider it necessary to go into a formal discussion of this subject. As regards the behavior of ships, it is quite sufficient to assume that the profile of a simple wave is trochoidal, and that the particles of water move in circles in a vertical plane, at right angles to the

* "Transactions of the Institution of Naval Architects," vol. v., pp. 30, 31.

* Dipping is the name given to the vertical oscillation of the ship as a whole, relatively to the surface of the water.

ridges and valleys of the waves. The consequences of this motion are briefly as follows, on the assumption that the depth of water is unlimited.

The diameter of the circle, in which a surface particle moves, is the height of the wave from hollow to crest. Particles, which in still water would be at a lower level, describe smaller circles in the same period. A horizontal plane (in the still water) is thus converted into a wave-surface of the same period, but of reduced amplitude of oscillation.* The velocity of the particles (and on this depends the *impact* of a wave) is simply the circumference of one of these circles divided by the periodic time.

If we consider a column of particles which is vertical in still water, that column oscillates in wave-water like corn-stacks in a gust of wind, and it also oscillates vertically. But it always slopes *towards* the crest of the wave, and the obliquity thus induced goes to enhance that due to the wave-slope ; so that, if we regard the profile of a wave, a small portion of water, rectangular when still, undergoes a double deformation, the horizontal surfaces following the wave-slope, and the vertical surfaces being deflected towards the crest ; both causes tending to increase the angular deformation, instead of to preserve rectangularity.

The crest of the wave being sharper than the hollow, and the quantity of water invariable, the horizontal plane which lies half way between valley and crest is higher than the mean, or still water, level ; and its elevation has been shown to be equal to the height due to the velocity of revolution of the particles.

Considered as trochoids, the wave profiles are traced by a point within a circle rolling *under* a horizontal line. The line midway between valley and crest is the line of centres.

The particles of water above the line of centres are moving forwards, as regards the direction of advance of the wave ; those below that line backwards. The particles in the front face of the wave are rising, and those in the rear face falling.

The wave whose period is $\frac{1}{n}$th of a second, has a length of $\lambda = \frac{g}{2\pi n^2}$, whence we find the number of waves to a second to be $n = \sqrt{\frac{g}{2\pi\lambda}}$. The velocity of wave propagation, that is to say, of the apparent advance of the wave in a deep sea, is $n\lambda = \sqrt{\frac{g\lambda}{n\pi}} = \frac{g}{2\pi n}$.

In other words, the speed of the wave crest varies as the periodic time, and the length of the wave varies as their product, or as the square of either.

The vertical disturbance of a particle, whose depth in still water would be k, is

$$h^1 = h\epsilon^{-\frac{2\pi k}{\lambda}}$$

h being the height of the surface wave.

No wave can be sharper than a cycloidal wave. For if the trochoid were looped, the particles in the loop would be unsupported. When the wave form tends to pass the cycloid, it must break.

The extreme observed height of ocean waves appears to be about 40 ft., and the greatest observed length 600 feet. ; these would have a periodic time of 11 seconds (roughly) ; their crest would advance at a rate of 33 knots an hour, and the velocity of the surface particles would be about 11.4 ft. per second. In short waves of the same height the particles of water move faster, in the inverse ratio of the period ; but the mass of moving water at the crest of the longer wave is the greater in the ratio of

$$\lambda - \pi h : \lambda^1 - \pi h,$$

where λ and λ^1 are the lengths, and h the height. If, therefore, the above mentioned wave were shortened to 200 ft. the surface particles would be moving at a rate of 20 ft. a second, while the mass of water in the crest would be about one-sixth. From such data it is easy to infer both the destructive effect of impact from the top of a wave, and the relative quantity of water which a ship would take on board in shipping a sea.

The front and rear of a trochoidal wave are exactly similar. Observation, as well as theory, shows that this is true to an extent not commonly believed for ordinary

* Drawings of the structure of a trochoidal wave will be found in the "British Association Reports" for 1844, plate 56 ; "Transactions of the Institution of Naval Architects," vol. i., for 1860, plate 7 ; vol. iii., for 1862, plate 3 ; vol. iv., for 1863, plate 10 ; vol. vi., for 1865, plate 10 ; "Shipbuilding : Theoretical and Practical" (Rankine). p. 69 ; Scott Russell : "Naval Architecture," plate 117.

waves. The exceptions are, when the wind is sufficient to push the tops of the waves at extra speed, and when the water shoals rapidly. But even here the relative steepness of the advancing face is exaggerated by most observers. Until a wave is about to break, the actual difference of slope remains very small.

It should be borne in mind that circular orbits and trochoidal wave-surfaces are only approximations, although near enough to the truth for purposes connected with the rolling of ships. In particular, it appears both from theory and observation that there is almost always some progressive motion combined with the orbital motion; and also that waves begin to break long before their crests attain a form so sharp as that of the cuspid cycloid; the two slopes at the crest of a breaking wave, cutting each other at right angles, or nearly so.*

The ordinary wave of a rough sea is usually an aggregate of waves of different period, and not unfrequently of different direction. For rough purposes, it is sufficient to draw each system of waves separately and add their corresponding ordinates, to get the resulting surface. This can hardly be relied upon in extreme cases; and, in any case, the motion of each particle is not according to any one or more wave systems separately; but it is a motion compounded of what would be due to each separately, if the others were not.

OSCILLATIONS OF A SHIP AMONG WAVES.

A treatise on "Shipbuilding, Theoretical and Practical,"† edited by Professor Rankine, contains in a very clear and condensed form, a *résumé* of nearly all that was known on this subject up to 1864, inclusive. The following abstract is chiefly taken from that work:

It is to be observed that what follows relates to the composition of the ship's oscillation with that of a simple trochoidal wave. The complete problem of a ship's behavior, depending as it does on wind, waves, rolling, pitching, dipping, yawing, variable head resistance, and lateral resistance, and direction of motion relatively both to wind and waves, is far too complicated even for statement, in an exact mathematical form.

If a ship floating passively in the water, and without any progressive motion, were wholly without stability, her centre of gravity, centre of buoyancy, and metacentre coinciding in one point, the motion assumed by that point would be exactly that of the centre of gravity of the mass of water displaced by the ship; that is to say, it would revolve once in each wave-period in a vertical circle of the same diameter with the orbits of the particles of water situated in the same layer.

This motion of the ship has received the name of *passive heaving*, that term being understood to comprehend the swaying from side to side, as well as the rising and sinking, of which the orbital motion is compounded.

Half the difference between the extent of heaving of the ship and the height of the waves is the extent to which, during the passage of the waves, her depth of immersion amidships is liable to be alternately increased above and diminished below her depth of immersion in smooth water. It appears that deep immersion and large horizontal dimensions, but especially deep immersion, tend to diminish the extent of the heaving motion of the ship as compared with that of the waves, and that the effect of those causes in producing this diminution is greatest among comparatively short waves.

The weight of the ship being combined with the centrifugal force due to her heaving motion, gives a resultant reaction through her centre of gravity, inclined to the vertical in a direction which, for passive heaving, is perpendicular to the wave-surface traversing the ship's centre of buoyancy (a surface which may be called the *effective wave-surface*); and that direction is the *apparent* direction of gravity on board the ship, as indicated by plumb-lines, pendulums, suspended barometers, lamps, spirit-levels, and the positions assumed by persons walking or standing on deck. The equal and opposite resulting pressure of the water, acting through the centre of buoyancy, is in like manner compounded of actions due to weight and centrifugal force; and it acts in a line normal to the effective wave-surface, that is to say, parallel to the resultant reaction of the ship. Those two forces balance each other, not when the ship's upright axis is vertical, but

* See "Philosophical Magazine," Nov., 1864.
† See pp. 72, 77, of that work.

when it is normal to the effective wave-surface; and when she deviates from that position, they form a righting couple tending to restore her to it. Thus the stability of a ship among waves, instead of tending to keep her steady, as in smooth water, tends to keep her *upright to the effective wave-surface;* and such is the motion of any vessel or other floating body having great stability and small inertia, such as a light raft. This may be called *passive rolling*, or *rolling with the waves.*

Passive rolling is modified by the inertia of the ship, which makes her tend to perform oscillations in the same periodic time as in still water, by the impulse and resistance of the particles of water against her keel and the sharp parts of her hull, which tend, under certain circumstances, to make her roll against the waves, that is, inclining towards the nearest wave-crest, and by other circumstances.

The tendency to keep upright to the effective wave-surface may be distinguished from the tendency to keep truly upright, by calling the former *stiffness* and the latter *steadiness.* In smooth water, stiffness and steadiness are the same thing; amongst waves they are different, and to a certain extent opposed; that is to say, the means used for obtaining one of those qualities are sometimes prejudicial to the other. Stiffness is favorable to the dryness of the ship, and to the power of carrying sail; steadiness is favorable to her strength and durability, and the safety of her lading, and in ships of war to the power of working guns in rough weather.

A ship, whose course is either oblique or transverse to the wave-crests, is made by the waves to perform a series of longitudinal oscillations, which may be called *passive pitching and scending.*

In all the oscillatory movements which a ship performs among waves, two series of oscillations are combined—those in which the ship keeps time with the waves, being her passive or forced oscillations, and those which she performs in periods depending on her own mass and figure, as in smooth water, being what may be called her free oscillations. The tendency and ultimate effect of the resistance of the water is to destroy the free oscillations after a certain time, so that the forced oscillations alone are permanent.

Passive heaving, or the motion of a ship when each of her particles performs an orbital motion, similar and equal to that of a certain particle of the water in which she floats, takes place when the ship floats amongst waves without having progressive motion.

The progression of the ship when under way alters the action of the waves upon her in various ways, which depend mainly upon the *apparent period* of the waves relatively to the ship—that is, the interval of time between the arrival of two successive crests at the ship, and upon the *apparent slope* of the effective wave-surface in a direction athwart the ship, the latter circumstance being connected mainly with forced rolling oscillations.

When the apparent periodic time of the waves is modified by the progressive motion of the ship, the time during which the forces act, which produce the heaving motion of the ship, is altered in the ratio of the apparent period to the true period; and the extent of the heaving motion is also altered in a proportion which, for moderate deviations of the apparent from the true period, varies nearly as the square of that ratio. This law, however, does not continue to hold for a very great increase of the apparent period, the extent of heaving being less than the ratio first mentioned.

Hence, the heaving motion of a ship is more extensive than that of the effective wave-surface, when the angle made by her course with the direction of advance of the waves is acute; and less extensive when that angle is obtuse.

Yawing, or swerving of the vessel from side to side by oscillation about an upright axis, is, when produced by the waves, the effect of the lateral swaying which forms the horizontal component of the heaving motion, taking place with different velocities, or in opposite directions, at the bow and stern of the vessel. The forces producing it are greatest when her course lies diagonally with respect to the direction of advance of the waves.

For reasons already stated a very light and stiff ship tends to float like a raft rolling *with the waves*, and assuming at every instant the same slope with the effective wave-surface.

Let a board, having very little inertia, and no stability, be placed so as to float upright in smooth water; then, when the

water is agitated by waves, that board will accompany the motions of the originally upright columns of water; that is to say, it will roll *against the waves*, inclining at every instant in a direction contrary to the slope of the effective wave-surface.

(TO BE CONTINUED.)

THE RENEWAL OF THE KING'S CROSS STATION ROOF.

From "The Engineer."

The following is an abstract of a paper read by Mr. R. M. Bancroft before the Civil and Mechanical Engineers' Society, at a meeting held on the 8th of December, 1869.

The Great Northern passenger terminal station at King's Cross was opened to public traffic in 1852, and its roof constructed during the two previous years, and was at the time a work which created some little sensation, as it was the largest span roof of the laminated type constructed in this country.

From designs of French roofs it appears that Colonel Emy, of the French Military Engineers, was the first person to draw public attention to the subject, by applying the system of the laminated timber arches in the construction of the roofs over the Riding Schools of Marac, near Bayonne, 65½ ft. span, and Libourne, 69 ft. span, about the year 1819. They were both semicircular, and made to form a complete truss to support the covering, by means of principal rafters tangential to the curves, and tied to the semicircular rib by a number of radiating clipping braces. The ribs were bent complete without treenails, and were maintained in their form by iron stirrups subsequently placed, and passing round the whole system at intervals, and by bolts going through the laminations in the intermediate spaces.

Mr. John Green, in the year 1827, made a design and model for a bridge, with timber arches resting upon stone piers. In 1833 the plan was adopted, and in 1837 it was put into execution at the Ouse Burn Viaduct of the Newcastle and North Shields branch of the North-Eastern Railway.

The late Joseph Locke, Esq., C.E., constructed a bridge upon the laminated arch principle for the Rouen and Havre Railway over the Seine and Epaulet, near Rouen. The arched ribs of this bridge were made 4 ft. deep by 1 ft. 6 in. wide, and formed by bending 16 planks 3 in. thick of Baltic timber, placed concentrically over each other, each course being fastened to those above and below it by oak treenails. These treenails were made to pass through two courses of planks into the third. The ribs were bent upon a platform on the ground to half the thickness of the ribs, thus dispensing with the necessity of centring, and were thus placed in position by a travelling crane, and the remaining depth of the rib was completed in place.

In bridges built upon this plan it was found, every time the girders or ribs deflected under moving loads, the concentric layers of planks detached themselves slightly from the layers that were respectively above and below them, so that a passage was formed for the admittance of aqueous vapors to the inside of the ribs, where a process of fermentation or "wet rot" rapidly developed itself. The King's Cross passenger station was erected on the site of the Small-pox Hospital in 1851–2, and therefore the roof has stood about eighteen years—a period much longer than the bridges built on the same plan. The principals of this roof were constructed upon a platform on the ground, to which chocks were secured at intervals of 4 ft. to 5 ft.; these were set out to a radius corresponding with the innermost layers of the planks, and were secured by means of clamps to the chocks. On this first layer a second series was laid and fastened with 3 in. wood-screws, 8 in. apart, and again clamped to the chocks, and so on until the whole thickness of the rib was completed, care being taken that all the planks broke joint.

The ribs were hoisted to place by three derricks, one placed against each wall, and a third in the middle of the span. A band of wrought iron, 4 in. by ⅛in., was finally placed round the topmost plank, and bolts passed through both iron and wood about 2 ft. from each other in the

centre of the rib. These laminated ribs in their turn support whole timber purlins, which carry the covering. As to the cause of decay in this roof, in the large quantity of timber used most likely some of it was in a sappy or wet state. The planks being so closely packed together, and painted over as soon as fixed, prevented the exudation of the moisture; and the intense heat of the sun during the summer months, as well as the vapor and sulphur from the locomotives and inefficient ventilation, assisted the fermentation going on inside the ribs, and caused rapid decay.

The scaffold for the construction of the roof, which I shall now briefly describe, contains altogether about 14,000 cubic feet of timber, and the estimated weight of it, when in full work, and including all iron and weights constantly being lifted, is 400 tons. It takes about 17 minutes to move it a distance of one bay, or 20 ft., out of which time the men take a rest of two or more minutes. The large wrought iron plate girders are constructed of such section that they may be hereafter used in bridges down the line. The stage has been designed so that no hindrance is caused to the traffic constantly passing underneath.

The wrought iron principals or main ribs are formed and accurately curved so as to fit in exactly between the old cast-iron shoes built in the walls on each side, the cast-iron spandrel fillings of the old roof being cut shorter to suit the new wrought iron ribs.

The intermediate ribs or rafters are of rolled iron 8 in. deep, with top and bottom flanges 5 in. wide and $\frac{1}{2}$ in. thick all over; the lower ends are fitted with new cast-iron corbel shoes on stone templates built into the station wall, and the upper ends rest upon T-iron supports 5 in. by 2 in. by $\frac{3}{8}$ in., and have wrought iron brackets riveted on each side, which are also riveted to the purlin stiffeners.

The first and sixth lattice purlins from the springing on each side are 1 ft. 6 in. deep, and formed of 5 in. by 4 in. by $\frac{1}{2}$ in. T-iron flanges, with flat bar bracing $2\frac{1}{2}$ in. by $\frac{1}{4}$ in., and T-iron stiffeners 5 in. by 2 in. by $\frac{3}{8}$ in. They are riveted at each end through the main ribs to each other, so as to be continuous from end to end. These purlins being of less depth than the main ribs, the difference (6 in.) is made up by a T-iron support 5 in. by 2in. by $\frac{3}{8}$ in. riveted to the web of the principal.

The second, third, fourth, and fifth purlins on each side of the rib are formed of 5 in. by 4 in. by $\frac{1}{2}$ in. T-iron bars, with $1\frac{1}{8}$ in. tension bars and $1\frac{1}{4}$ in. struts. The ends of these purlins are fixed to angle-iron jaws riveted to main ribs, and to which also the ends of the tension bars are bolted.

In the last bay at the north end the purlins are of a stronger section, and composed of 5 in. by 4 in. by $\frac{1}{2}$ in. T-iron for the flanges, and 5 in. by 2 in. by $\frac{3}{8}$ in. T-iron bracing bars to sustain the lateral thrust of the roof, and the intermediate rafter in this bay is carried over from wall to wall.

An angle iron bar 6 in. by 3 in. by $\frac{3}{8}$ in. is riveted to the top of the first purlin on each side, and a ventilating opening formed above it, by means of flat bars bent to horse-shoe shape, and carrying an angle iron bar $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{3}{8}$ in., to which the glazing bars are riveted, the latter being inverted T-irons 3 in. by $1\frac{3}{4}$ in. by $\frac{3}{8}$ in.

A double angle or Z-bar 4 in. by 2 in. by $\frac{3}{8}$ in. is riveted on the top of the second, third, fourth, and fifth purlins on each side, and to the main ribs where they occur, to which the glazing bars are riveted, and are fixed in their place so as to give a perfect bed for carrying the glazing bars.

An angle iron bar 6 in. by 3in. by $\frac{3}{8}$ in. is riveted along the top of the sixth purlin on each side, and to the main rib where they occur, to which T-iron arched bearers 4 in. by 3 in. by $\frac{1}{2}$ in. are riveted to carry the raised portion of the roof for ventilation. On the arched bearers longitudinal angle irons 4 in. by 2 in. by $\frac{3}{8}$ in. are riveted for carrying the glazing bars. At the centre these angle-irons are 9 in. apart, and the open spaces are covered with a wrought iron capping, No. 12, B. W. G., secured by brackets $1\frac{1}{4}$ in. by $\frac{1}{4}$ in. every 3 ft. 3 in. apart. The main ribs are 20 ft. apart, centre to centre, and are hoisted to place in seven different pieces, and the total weight of iron work in one bay of 20 ft. is 17 tons 3 cwt. 2 qr. 14 lbs.

The whole of the wrought iron was specified to be of full scantling, and capable of bearing a tensile strain of at

least twenty tons to the square inch. All the plates in the flanges of the ribs are planed truly square on each edge, and those in the webs of the ribs are planed at their butting joints. The junctions of bars and angles and T-irons are fitted to butt truly together. The rivet holes throughout were specified to be punched one-sixteenth smaller than required, and rimered out to the proper size when fitted in place, and no drifting or other straining of the iron being allowed under any circumstances. The rivets, bolts, and nuts were specified to be of iron cable of bearing a tensile strain of at least twenty-four tons to the square inch. The bending of angle and T-irons and the riveting to be done hot.

The whole of the timber is of the very best red Riga, thoroughly seasoned.

Fir packings with stop chamfered edges, are fixed by 3 in. by ½ in. coach screws to the main and intermediate ribs. They are carefully bent to the curved portion of the ribs, and bedded down in thick white lead, those on top of the main rib being composed of No. 2 wrought and stop chamfered packing 6 in. by 3 in., and that on intermediate rib being 9 in. by 3 in., also wrought stop chamfered.

The roof, for its whole length, and to the height of the first purlin on each side, is covered with 1½in. wrought—one side grooved, tongued and chamfered—red Riga, boarding securely nailed down to the packings described above; and a wrought one-side fascia 11 in. by 1½ in. with chamfered edge, and scribed between the main and intermediate ribs, is fixed against the brickwork at the bottom of the boarding along each side on the inside of the roof.

RAILWAY BRIDGE AT HAVRE DE GRACE.

From "The American Railway Times."

One of the finest and most substantial examples of American railway bridge construction of the present day, is to be seen at Havre De Grace, where the Philadelphia, Wilmington, and Baltimore railway crosses the Susquehanna river. The transit was formerly conducted with train ferry boats, which were frequently exposed to danger upon their passage, the river at this point being about 3,300 ft. in width. The bridge which was constructed from the designs and under the superintendence of Mr. G. A. Parker, C. E., is of timber, mainly on the Howe principle of truss. It consists of twelve spans of 250 ft. 9 in. in the clear, and a draw span of 174 ft. 9 in. The total length between the abutment piers is 3,273 ft. 9 in. The superstructure is supported by thirteen piers built of stone laid in cement, with caissons of boiler plate which reach to a short height above the line of the floating ice. From this point the piers are finished with dressed masonry laid in courses. The draw pier is circular and is 24 ft. 8 in. in diameter at the top of the caisson. The other piers are each 35 ft. 4 in. in length, and 8 ft. in width at the top of the caissons, and have a width of 7 ft. 3 in. at the top of the masonry. Besides the piers which carry the superstructure, there are at the draw span two guard piers, one above and one below, and which serve to protect the draw pier from injury, and aid ships in passing. The unstable nature of some parts of the bed of the river, together with the unusual depth of the water, and the occasional violence of the ice freshets at the point where the bridge is carried across, has surrounded the work with many engineering difficulties. The method adopted in constructing the piers was specially resolved upon in order to meet the exigencies of the case, and the results have been thoroughly satisfactory. The masonry was laid within wrought iron water-tight caissons, which were fastened to timber platforms and lowered gradually as the building of the masonry progressed on to a prepared foundation of piles. In some instances, the lowering was assisted by screws; in others the work was guided to the bottom by temporary guide piles. One of the piers was lowered by means of six 3½ in. screws, 56 ft. in length, to a pile foundation in water generally over 40 ft. deep. The cost of this fine structure was nearly £400,000, and, considering it is only a single-way bridge, wood-built, and on a line of railway only 100 miles in length,

this is a very large amount. But the public are great gainers by it, inasmuch as the time of travel is greatly shortened between Philadelphia and Baltimore, as well as on account of the absence of danger which previously existed in the old ferry passage. It occupied a thousand men four years in constructing, and, considering all the engineering difficulties encountered and successfully overcome, as well as the convenience afforded to the public by the bridge, we may pronounce it one of the leading engineering works of the age.

The above from the London "Mechanics' Magazine" pays a handsome tribute to the engineering skill shown in the construction of this bridge; but we seriously hope that this particular bridge will be the last wooden bridge in the United States of any considerable size for railway purposes, that our contemporary will have an opportunity for commenting upon. The adoption of so perishable a material in lieu of iron, we think will be found a great mistake —not a mistake of the engineer, perhaps, because probably the material of the superstructure was dictated by others, or by considerations over which he had no control. We trust the use of wood in the construction of long railway bridges is past. For ultimate economy, and for safety, there is no question which has not been settled in favor of iron.

RELATIVE ILLUMINATING POWER OF DIFFERENT SUBSTANCES.

From "The Practical Mechanic's Journal."

Taking as the unit of comparison the light given forth by the consumption in the usual form of lamp of one imperial gallon of Young's paraffine oil, Dr. Frankland has stated that to produce the same quantity of light 1.26 gallons of petroleum (*i.e.* natural oil) must be consumed. That also a total of light equal to either of the above is produced in burning by 18.6 lbs. avoir. of paraffine candles, 22.9 lbs. avoir. of sperm candles, 26.4 lbs. avoir. of bleached wax candles, 27.6 lbs. avoir. of stearine candles, or 39 lbs. of tallow candles. The great economy of those liquid hydrocarbons is sufficiently evident, though there can be no doubt that the deficiencies in luminiferous power of the candles is due in great part to their *being* candles, and not *liquids* burning with the advantages of a lamp.

But even this is not all that can be said in favor of the liquids. The light-giving power of candles scarcely admits of any material improvement,—to increase the light is to increase the intensity of the heat of the flame, which is to swill and waste the substance of the candle. In the liquids, however, there is no mechanical or chemical difficulty in increasing the quantity of light, to an extent of which we venture to say no clear notion has yet been formed, by employing oxygen wholly or partly in place of atmospheric air as the supporter of the flame.

Now that oxygen can readily be obtained by means of permanganate of lime at a price low enough to admit of its domestic use, we do not know of a more fruitful-looking speculation for those engaged in the improvement of instruments of illumination than to devise a paraffine oil-burning portable lamp, with a portable supply of compressed oxygen, to burn a known number of hours. The danger of using such a lamp, once properly constructed, would probably be less than that of the common camphene or petroleum lamps of the shops; for most of the accidents have arisen from awkwardness in upsetting these lamps in filling or lighting them, or with the oil-cans in filling. With oxy-paraffine oil lamps, the whole lamp should be delivered at the house of the consumer ready for use, and as with its oxygen reservoir it would be heavier and more bulky than the present lamps, so would it be safer as to upsetting, and accidents while filling put an end to. The same objections as against the blinding intensity of the focus of light in oxy-hydrocarbon lights as respects their use in public places, do not apply to their use in apartments, where the light may and ought always to be above the eye and shaded.

When we consider what is done easily, habitually, and at a profit, in Paris, in de-

livering about that city aërated water in "siphons" or gazogene bottles, and also frozen caraffas, *i.e.*, bottles of common water solidified into a block for cooling other water or liquors, of which alone half a million caraffas are said to be circulated daily in summer time in Paris, we see sufficient indications of what may be done at a profit in supplying from central depots other domestic implements, such as those for giving light. It no doubt will occur to every one that such a project would find a powerful competitor in the existing gas companies; these companies, however, do, and no doubt will continue as long as they can in their old jog-trot; they give, in London at least, gas of miserably bad illuminating power, and are not likely to attempt any radical methods of making it more luminiferous in the houses of the consumers. It does not follow that, although cheap as gas, such as it is, may relatively be yet, measured by the light afforded for 20s. sterling, paraffine oil, well burnt with oxygen, might not give the same light much cheaper. This much is certain, that it would afford whatever illumination could be needed, in a far more wholesome way than it is obtained by the consumer of London gas. How it is that public checks and counter checks, and all the apparatus of public officers paid for testing and reporting upon the qualities of our London gas, seem to be costly methods of finding berths for officials whose reports have no result, and indeed seem to be generally of the mildest and most "how not to do it" character, we are too much outsiders to know or even guess. But from unhappy personal experience we can (through the winter) testify that the gas supplied to London and to the south side in particular, is such as ought not be tolerated for a day, and such as would not be tolerated in Paris or Berlin, nor indeed in any capital but London, where genuine municipal jurisdiction and real action in such matters seems to be a succession of costly shams; or in New York, where it is said to be so corrupt that bribery is the rule and can do what it pleases. Possibly, something of the sort even here is not unknown to gas manufacturers, and certain revelations of a year or two ago as to the surveillance of gas company directors over their own *employés*, were not calculated to add confidence to the public as to what goes on to influence the character of the final product which reaches their parlor gas-burners. The fact is, however, that London gas at the south side, and we believe it is no better in other quarters (unless in exceptional cases and at exceptional prices), is so loaded with impurities that silver plate left out upon a sideboard is tarnished brown in a single night of damp weather, and within a fortnight in winter becomes absolutely black with sulphuret of silver deposit, while the ammonia present is sufficient to eat through and through any thin pieces of brasswork exposed above the gas flames, in a very few months; gilding also is rapidly and irremediably tarnished by action upon the alloy in the gold, as the microscope proves.

To prattle of sanitary care for the public, and yet leave, or rather compel them, for they have no remedy, to breathe the air of rooms in which such gas as this is consumed and such products evolved, is monstrously absurd. Were the public once assured that they could obtain good and ample light from paraffine, which holds neither sulphur nor nitrogen compounds, to damage their health and their property, and at a cost not much exceeding that of coal gas, for equal yields of light, it would soon go hard with the present gas-making interests and gas-supervising philosophers, or all of them would have to mend their ways.

TREATMENT OF THE SEWAGE OF THE CITY OF RHEIMS.—MM. Houzeau, Devëdeis, and Holden, in a lengthy paper in "Les Mondes," detail the results of a series of experiments made on a sufficiently large scale to form a proper opinion as to value and permanent applicability. The processes which have been applied are: (1) Treatment with sulphate of iron and lime; (2) treatment with lignite and lime; (3) treatment with small coal (dust, rather) and a small quantity of sulphate of iron and lime. The two first processess yield a manure; the last a fuel. The city of Rheims is situated on and near the banks of the Vesle, and contains, exclusive of the large garrison, a population of about 61,000 inhabitants. According to a report of M. Maridort, Professor of Chemistry at this place, the process, by means of the use of lignite, is a complete success.

MANUFACTURE OF WHITE LEAD.

From "The Mechanics' Magazine."

White lead is generally manufactured in England by placing the metal over earthenware pots containing an acid, piling them up in layers and covering them over with spent tan. An improvement upon this somewhat slow process has been patented by Mr. Joseph Major, of Middlesex, in conjunction with Mr. W. Wright and Mr. G. H. Jones. The invention consists in the manufacture of white lead in closed chambers, heated artificially, and without the employment of spent tan or earthenware pots. The necessary vapors and gases are fed into the chambers containing the compounds to be converted into white lead. The invention further relates to the uses of the vapors and gases under pressure in a closed chamber, although the white lead can be produced by this invention without the gases and vapors being submitted to pressure, but more time is necessary.

The apparatus employed in the manufacture embraces independent apparatus for freeing the vapors and gases and for regulating their supply, and for keeping the lead in continuous circulation through the closed chambers. This is accomplished by revolving surfaces inside a chamber actuated by machinery, upon which surface the lead is placed. The invention further consists in a method of treating the white lead, when produced, so as to decompose and remove any remaining acetic compound and replace the necessity of washing the material. This is accomplished by currents of heated vapor or gases and air brought in contact with the material in the closed chambers, and circulating through them in contact with the materials, so as to deprive them of any superfluous compounds. They can, however, be washed and finished in the ordinary way. The article thus manufactured is completed by any of the well-known methods.

In our engraving Fig. 1 represents chambers constructed for carrying out the first part of this invention. A A^1 represents the chambers; B B the wall; C C the roof; and D the separating wall. These chambers are shown with different arrangements of the shelves, for causing the gases to circulate perfectly and to permeate in a complete manner the lead under process of conversion into white lead. The chamber A has shelves, *a a*, made of any suitable material, so disposed as to cause the vapors and gases to circulate in the direction shown by the arrows, as well as to permeate directly through from the top to the bottom, or *vice versa*. The second chamber, A , shows an arrangement by which the circulation is effected longitudinally. Steam is supplied to these chambers both for heating and for furnishing moisture by the pipes, *b b*, shown in the chamber A. *c c* are the flues, so contrived as to cause the heated gases circulating through them to pass through several chambers or through one only, or to the chimney, *d*, without passing upwards through the chambers, the course of the currents of heated gases being regulated by the dampers shown in the flues, *c c*. The lead is placed upon the shelves, *a a*. The vapor of water and ammonia and acids and gases generated from carbonaceous materials for furnishing carbonic acid are fed into the chambers, A A^1.

The mode of providing the necessary carbonic gases to the chambers is as follows: C^1 is a charcoal or fuel burner and furnace, made so as to be self-feeding by the upper box, D^1 D^1, and provided with a supply pipe, E, by which the combustion may be sustained by pressure from a fan. F is an oxidizing valve, which regulates the air admitted for effecting the combustion of the fuel. The products of this combustion pass under and through the boiler, H, by the internal flue, G. The products, after passing through the boiler, pass under the vessels for generating the gases. One of these generators is shown at L. M is a pouring pipe; N is an exit pipe; K a steam pipe adapted to the generator. By the generator gases can be made and sent to the chambers, A A^1 by the pipe, N. P represents an auxiliary exit or chimney used as a by-pass when necessary, as when the combustion is needed in the furnace, C^1, and the products are not wanted to circulate through the chambers, A A^1; *d* is the working chimney, which receives the products from the chambers by either of the valves, c^1 c^1, for sealing the chambers when required; I is the main steam pipe.

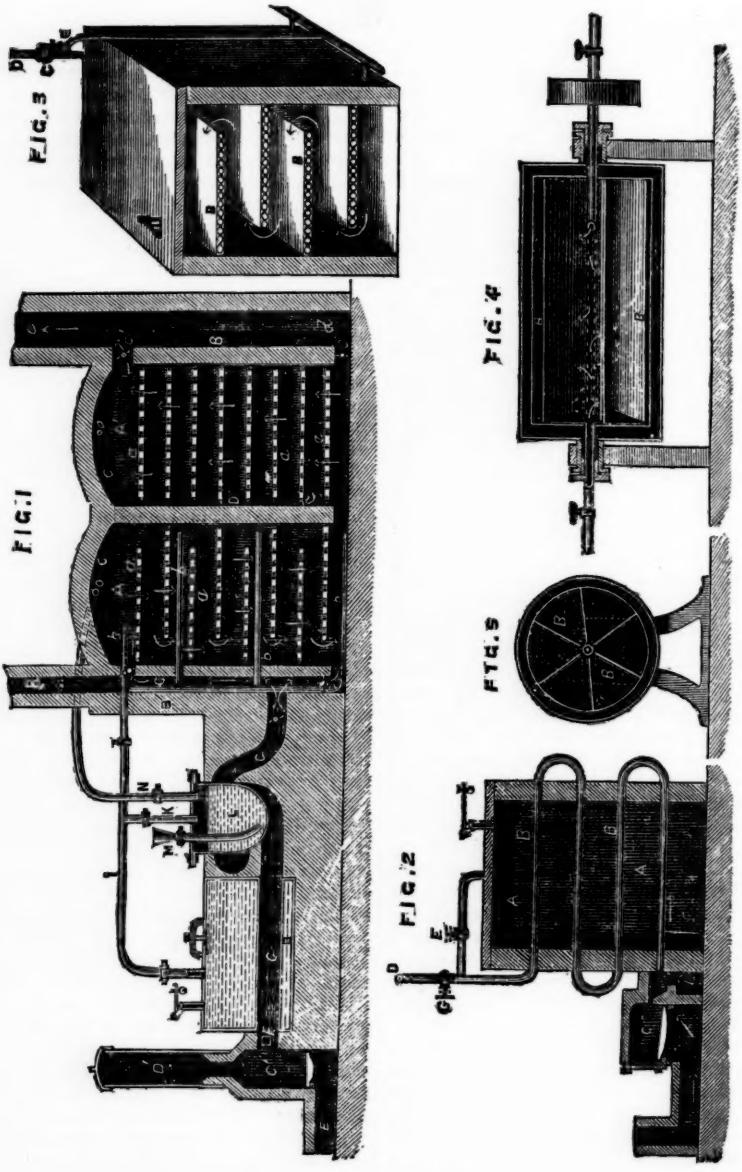


FIG.1
FIG.2
FIG.3
FIG.4
FIG.5

The mode of operating is as follows:—The lead, which is prepared so as to expose a large amount of surface, is placed on the shelves in the chambers; the chambers are then closed, and heated to a temperature of about 120 deg. to 140 deg. Fahr. Steam is then directed into the chambers so as to convert a portion of the metal into hydrated oxide or oxide; this is continued for from ten to twenty hours. The chambers being raised to a temperature of about 120 deg. to 140 deg. Fahr., the next step is to generate vapors in the generator, L. These vapors are conducted by the pipe, N, to the upper part of the chambers at O. In these operations a sub-salt of lead is produced upon the lead in the chamber. The next step is to treat the lead with carbonic acid. This gas is prepared in the fuel burner, C [1], and is fed into the chambers and caused to circulate regularly in contact with the materials so as to convert the sub-salts into carbonate of lead. During the conversion of the lead in these stages of the operation, the temperature of the chamber is preserved at about 140 deg. Fahr., and the successive steps of the operation are repeated, care being exercised to regulate the supply of steam so as not to wash the lead nor to have it in too dry a state for treatment until the whole is converted into white lead.

Fig. 2 shows the arrangement of a pressure chamber, A, fitted with valves, E E, for the purpose of regulating the pressure within. B B are pipes for circulating steam from a boiler, or hot air and gases from the fuel burner, C, and forming also the shelves or supports for the lead. These pipes communicate with the chimney at D, which is provided with a stop valve, G, so that the products of combustion, after passing through the pipes of the chamber and heating it, can be forced into the interior of the chamber and brought in contact with the lead, and thus after being employed as a means of heating the chamber when the same is heated by the gases from the fuel burner C, these gases are utilized in the decomposition of the sub-salts and in the formation of white lead; the heated gases, however, may be employed for heating purposes alone, and carbonic acid supplied to the chamber from some independent source in a heated condition or not. Fig. 3 shows the arrangement of the shelves in the chambers so as to cause circulation of the gases within it, the course of these currents being at right angles to those within the hollow shelves or pipes through which the heating current passes, and on which the lead or its compound is placed. The mode of operating is the same in the pressure chambers as that already described.

When circulating chambers are employed, in which the metal is kept in motion, the inventors have two cylinders, as shown in Figs. 4 and 5; the inner one, which contains the lead, is made to rotate. It is a cylindrical vessel, B, with a number of radial shelves or gratings on which the lead is placed. These chambers are all fitted in a similar manner to those we have already described, and are fed with gases or vapors in a similar manner. The whole of the chambers have air-tight doors or openings for charging and discharging materials in manufacture.

White lead so manufactured can be finished in the usual manner by washing, grinding, etc., but the inventors treat their products in a novel manner and on a new principle. They decompose any salts of lead remaining other than those proper to white lead, and this they accomplish as follows:—They pass into the chambers when containing the lead compounds produced in manufacture, ammoniacal compounds, and so decompose any remaining salts of lead other than those proper to white lead. After this treatment they raise the temperature of the chamber and its contents so as to remove the ammoniacal compound so formed, and thus avoid the necessity of washing. The lead is afterwards finished and prepared for general uses in the customary manner. White lead manufactured according to this invention is said to be free from all contamination, and is pure white lead. The process relieves the operation from its present dangerous tendencies, the workmen are never exposed to any dangerous or deadly fumes, nor is there any chance of loss of material in the process of manufacture. Time is also economized, the usual period required being about three months, whereas the inventors state that they can fully operate upon lead so as to convert it into white lead in from fourteen to twenty-eight days, according

to the substance of the material operated upon, and in a pressure chamber they can produce it in even less time.

Professor E. V. Gardner, of Berners College, Oxford street, has practically carried out this patent in all its bearings, and his exhaustive report is now before us. Upon all points the Professor obtained the most satisfactory results, as will be seen by the following extracts from his report: "I do not hesitate to state, from my experience in these experiments, which I would observe are not laboratory experiments but practical operations (the chamber fully worked out being 4 ft. by 2 ft. 6 in. by 2 ft. 6 in., and containing 3 cwt. of lead), that white lead could be made by Major's process in 28 days—*i.e.*, if the process were well conducted day and night unceasingly, and no time lost in raising the heat of the chambers day by day, as has been unavoidably the case in these experiments. I am also of opinion that the conduct of this process on an extensive scale, say of 500 or 1,000 tons, would show even more favorable results, and afford means of large and economical reductions in the cost of manufacture." Concerning the finishing process, the Professor writes: "According to the plan at present pursued in making and finishing white lead, the material from the converting vessels being washed and ground, the cost is about $7 per ton. By this process (according to Major's patent) the converted material is treated with vapor of ammonia, so that any remaining acetate is decomposed; the salts of ammonia thus formed are then removed by currents of heated air, or by superheated steam. This newly improved finishing process, it is to be observed, is completed without removing the converted material from the chambers in which it has been treated."

RAILWAY BRAKES.

From "Engineering."

A railway train moving at a speed of 60 miles per hour, or 88 ft. per second, has the same velocity as a body would acquire in falling freely from a height of 120.25 ft.; and if it were possible to change the direction of its motion so that it should be projected directly upwards, it would, if not checked by frictional or other resistances apart from that of gravity, rise vertically to the height just mentioned before coming to a state of rest. In other words, for each pound of the train's weight there are 120.25 foot-pounds of "work" which must be expended, either in overcoming the frictional resistance caused by the brakes, or in some other way, before the train can be brought to a stand. Again, a train moving at a speed of 30 miles per hour, or 44 ft. per second, has the same velocity as a body would acquire in falling from a height of 30.06 ft.; and there are therefore but 30.06 foot-pounds of "work" stored up in it for each pound of its weight, and the work to be done in stopping it is thus only one-fourth of that required in the first example. The work to be done in stopping a railway train, in fact, varies, as is—or ought to be—well known, as the square of the speed at which it is moving; and this being the case, it is of the utmost importance that in all experiments made to be determine the relative value of different railway brakes, the speed at which the train is moving when the brake is applied should be known exactly, and not merely guessed at, as happens in but too many instances.

The manner in which a slight error in the determination of the speed at the time the brake is applied will totally destroy the value of the results obtained, is clearly shown by the subjoined table. In this table the first column shows the speed of the train in miles per hour; the second column the equivalent velocity in feet per second; and the third column the height, in feet, from which a body must fall freely in order to acquire the velocity given in the preceding columns. If now it was possible to apply to a railway train in motion a steady resisting force equal to its own weight, this would be equivalent to changing the direction of its motion to a vertical one, and the train would be brough to a state of rest after having passed through a space equal to the height given in the third column of the table. Practically, however, it is impossible to oppose such a resistance as

this to the motion of a railway train—at all events on ordinary railways—and the most that can be done (unless the engine is reversed and steam admitted against the pistons) is to employ continuous brakes, and apply brake blocks to all the wheels of the train simultaneously, the pressure of the blocks being regulated so that the wheels, although just on the point of skidding, are not actually skidded. Even this result could not be obtained—unless accidentally—in regular working, for of course the pressure which would produce skidding of the wheels in one state of the rails would not do so in another, and, moreover, no system of continuous brakes would enable the pressure of each brake block on its wheel to be accurately adjusted according to the load that wheel might be carrying at the time of the brake being applied.

Practically, however, we may assume

Speed of train in miles per hour.	Speed of train in feet per second.	Height from which a body would have to fall to acquire the velocity given in preceding column.	Distance which would be run by the train against an opposing resistance of 10 lbs. per ton or 1–224th of its weight.	Time occupied in running the distance given in the preceding column.	Distance which would be run by the train against an opposing resistance of 224 lbs. per ton or 1–10th of its weight.	Time occupied in running the distance given in the preceding column.	Distance which would be run by a train against an opposing resistance of 448 lbs. per ton, or 1–5th of its weight.	Time occupied in running the distance given in preceding column.
Miles.	feet.	feet.	feet.	m. s.	feet.	sec.	feet.	sec.
60	88.	120 25	26,936	10 2	1,202.5	27.3	601.7	13.7
55	80.7	101.12	22,650.8	9 21	1,011.2	25.	505.6	12.5
50	73.3	83.6	18,726.4	8 30	836.	22.7	418.	11.4
45	66.	67.6	15,142.4	7 39	676.	20.4	338.	10.2
40	58.7	53.5	11,984	6 48	535.	18.2	267.5	9.1
35	51.3	40.86	9,152.6	5 57	408.6	15.9	204.3	7.9
30	44.	30.06	6,733.4	5 6	300.6	13.7	150.3	6.8
25	36.7	20.9	4,681.6	4 15	209.	11.4	104.5	5.7
20	29.3	13.3	2,979.2	3 24	133.	9.1	66.5	4.5
15	22.	7.5	1,680	2 33	75.	6.8	37.5	3.4
10	14.7	3.35	750	1 42	33.5	4.5	16.7	2.3
5	7.3	0.83	186	0 51	8.3	2.3	4.1	1.1

that, unless the rails are in a very "greasy" state, the use of a good system of continuous brake applied to all the wheels of a train will give a retarding force equal to one-fifth the weight of the latter, while if the brake-blocks are applied to half the wheels only, the retarding force will equal one-tenth of the weight of the train, and so on; the variation in these amounts due to atmospheric resistance being disregarded in the following calculations, as their consideration would only lead to unnecessary complications. This being the case, let us now see how an error in determining the speed at the moment the brake is applied, will effect the result obtained. If a train is subjected to a retarding force equal to one-fifth of its own weight, the space through which it will pass before being brought to a state of rest will be five times as great as if the retarding force was equal to the weight of the train; or, in other words, the distance it will traverse will be five times that placed opposite the corresponding speed in the the third column of our table; or will be equal to that found in the eighth column of the latter. This space is the minimum distance in which a train running on a level line could be brought to a stand by a resistance equal to one-fifth of its weight; and in practice the distance run by the train before the stoppage is effected will always be greater than this, on account of the time lost in causing the brake blocks to exert the requisite pressure upon the wheels. The more perfect the arrangement of the brake the less this loss of time is; and in comparative trials, therefore, it is of importance to determine this loss accurately; but, as we shall now show, it is quite impossible to ascertain this loss with any degree of accuracy, unless the observers have a precise knowledge of the speed at which the train is moving.

For instance, let us suppose that a

train, moving at the rate of 55 miles per hour on a level, to be brought to stand after having run a distance of 1,000 ft. past the point at which the brake was applied, the brake being so constructed as to bring into action a retarding force equal to one-fifth the weight of the train. Referring to our table, it will be seen that a train, moving at 55 miles per hour, would run 505.6 ft. against an opposing resistance equal to one-fifth its weight; and it follows, therefore, that in the case supposed in our example the train must have run 1,000—505.6=494.4 ft. before the brake was brought into action.* The speed of 55 miles per hour is equal to 80.7 ft. per second, and the time lost in applying the brake would thus be $\frac{494.4}{80.7} =$ 6.12 seconds. Let us suppose now that the observers in the case we are imagining, instead of taking the speed of the train at its correct amount, namely, 55 miles per hour, had estimated it at 60 miles per hour, equal to 88 ft. per second. Under these circumstances the distance to be set down as that which would be run by the train against a resistance equal to one-fifth its weight would be—as will be seen from the table—601.7 ft., and this distance subtracted from the 1,000 ft. leaves 398.3 ft. as the distance run by the train before the brake was got fairly to work; while, the speed being supposed to be 88 ft. per second, the time corresponding to this distance will be $\frac{398.3}{88} =$ 4.52 seconds, or about 27 per cent. less than what we have shown to be the real time. At lower speeds than those we have chosen for our examples a mistake to the extent of 5 miles per hour in estimating the speeds would lead to still more serious errors, as our table clearly shows.

In the foregoing examples we have assumed—for the purpose of showing more clearly the influence of an error in the determination of the speed—that the retarding force of the brake was equal to one-fifth of the weight of the train; and we shall now proceed to explain how, in practice, the amount of retarding force actually applied can be correctly ascertained, it being premised that in order to do this it is absolutely necessary that the train should be fitted with an accurate speed indicator. This being the case, let the brake be applied, and after it is fairly in action, and the train becoming retarded, let the speed, on passing some definite object, be accurately noted. This being done, and the distance run by the train past this object before stopping being subsequenty measured, we have all the elements for calculating the retarding force. Let us suppose, for instance, the speed of the train on passing the object, to have been 30 miles per hour, and the distance subsequently run 200 ft., then referring the table (third column) we find the distance which would have been run, if the retarding force had been equal to the weight of the train, would have been 30.06 ft., and dividing 200 ft. by this we get $\frac{200}{30.06} = 6.65$, or the retarding force must have been equal to $\frac{1}{6.65}$ equal to 15.037 per cent. of the weight of the train. If the train should be running up or down a gradient when this experiment is made, the result obtained should be reduced to the equivalent result on a level by deducting or adding, as the case may be, the retarding force, or the force tending to assist the forward motion of the train, due to the gradient. Thus, if the train was *ascending* an incline of 1 in 100 at the time the above experiment was made, 1 per cent. would have to be deducted from the retarding force, calculated in the manner we have explained, in order to get the equivalent retarding force of the brake on a level line; while, if the experiment was made on a *descending* gradient of 1 in 100, 1 per cent. would have to be added to the calculated result. The actual retarding force being known, the time lost in applying the brake can be readily ascertained in the manner we have already explained.

Although there are many cases in which, for the purpose of ascertaining the comparative value of different classes of brakes, it is desirable that the time lost in bringing the apparatus into action should be separated from that required to stop the train after the brake-blocks are actually applied, yet in the majority

* In this and the following calculation we have, for the purpose of simplifying matters, supposed that the pressure of the brake-blocks is applied to the wheels suddenly, instead of gradually. In reality the brake-blocks begin to exercise a retarding force from the time they first touch the wheels, the force becoming greater as the pressure applied to the blocks becomes more intense; but in our examples we have supposed the full pressure to be exerted at once, and that there is no retarding force until this pressure is attained.

of instances, probably, railway men are content to ascertain that a train fitted with brake-blocks on so many wheels, can, when moving at a certain speed, be brought to a state of rest within a certain distance; and they value the brake accordingly. In this case an excellent estimate of the value of any given brake may be obtained by measuring the distance run by the train after its application, and dividing this distance by that which the train would have run if the retarding force had been equal to its own weight. For instance, let us suppose that a train moving at the speed of 40 miles per hour, runs a distance of 500 ft. after the application of the brake; then, referring to the table, it will be seen that the distance in which a train would stop under such circumstances, if subjected to a retarding force equal to its own weight, would be 53.5 ft., and dividing 500 by this, we get $\frac{500}{53.5} = 9.32$, this number forming a kind of "figure of merit," by which the performance of this brake can be compared with others, the *lower* this figure the better being the performance. In making this comparison, however, it must be borne in mind that it is not a fair one unless the brakes between which it is instituted are both applied to the same proportionate number of wheels of the train; neither does it form a good method of comparing brakes tried at widely different speeds, some brakes giving far better "figures of merit" at low speeds than high ones, while others give much more nearly equal figures at all speeds. This, however, is a matter of which we intend to speak on a future occasion, when we shall treat of the manner in which the construction of a brake affects its efficiency at different speeds. In conclusion, we may remark that in calculating the "figures of merit" just mentioned, accurate information as to the speed of the train when the brake is applied is absolutely essential to give them any value. For instance, if in the example we have given, the speed had been wrongly estimated at 35 instead of 40 miles per hour, the divisor would have become 40.86, and the "figure of merit" instead of being 9.32 would have been $\frac{500}{40.86} = 12.23$, a widely different result.

THE USE OF GAS AS FUEL.

From "The American Gas-Light Journal."

During the last few years heating with gas in different ways has been introduced, and doubtless this mode of heating would enjoy a far more extensive application on account of its cleanliness and simplicity, were it not for the high price of illuminating gas on the one hand, and the impracticability of generating gas on the principle of Sieman's gas generator, on a small scale, on the other hand. The supply of a cheap article seems, therefore, very desirable; and this object we learn is about to be realized by the gas works now building at Furstenwald near Berlin. The gas is to be generated from lignites at Furstenwald, about twenty-two miles from Berlin, and carried to the latter city by means of pipes. For this purpose there will be erected at Furstenwald 12 buildings, each 105 by 62 feet, with an aggregate of seventy furnaces, each containing 10 retorts. The furnaces will be provided with Sieman's regenerator. The gas after having been freed from tar, water, etc., by passing through condensers, is brought to Berlin through a series of pipes 4 ft. in diameter, into which it is forced by 4 cylinder-blasts of 7 ft. $7\frac{1}{2}$ inches diameter and 6 ft. stroke. The blasts are propelled by 4 steam engines of 6 ft. stroke, and 360-horse power each—capable, however, of working up to 500-horse power. The pressure of the gas in the pipes is intended at 16 ft. water, equal to about 7 lbs. to the sq. in., since this comparatively high pressure allows of a smaller diameter of the pipes, and seems to offer a lower one in many other respects. The pipes are made of quarter-inch boiler plates, and not buried, but laid above ground, to render them at any time easily accessible, and supported in an appropriate manner by stone pillars. Under a pressure of 16 ft. water, the pipes will deliver 407 cubic ft. per second.

At Berlin the gas will be stored in 12 gasometers, each 154 ft. in diameter and 40 ft. high, having therefore a capacity

of about 750,000 cubic ft. From these gasometers the city is to be supplied. From experiments made by Dr. Zuirck of Berlin, it seems that a gas of good heating quality can be made from the Furstenwald lignites. The components of the gas at a specific gravity of 0.5451 is said to be as follows:

Hydrogen	42.36	per cent.
Carbonic oxide	40.00	" "
Heavy carburetted hydrogen	11.37	" "
Nitrogen	3.17	" "
Carbonic acid	2.01	" "
Carburetted hydrogen (condensable)	1.09	" "
	100.00	

If this composition of the gas can be regularly maintained throughout, it will answer its purpose perfectly. The experiment shows that 3,000 cubic ft. of gas are equal in heating power to one ton of lignite, or one-third ton of hard coal. The price at Berlin is rated at twelve and a half cents gold per thousand cubic ft., and the equivalent of one ton of hard coal will cost in Berlin $1.12½ cts. gold. The capacity of the works are calculated at 9,500,000 cubic ft. per annum, or about ten and two-third millions per day, which it is said will cover the demand of about half the city.

ECONOMICAL STEAM-ENGINES.*

From "The Engineer."

Certain individuals hold that economy in the consumption of coal is the true and only test of the value of a steam-engine. They maintain, in pursuance of this theory, that complexity of arrangement, multiplication of parts, and increase of first cost, are not to be considered objectionable, provided the annual outlay on fuel is reduced to a minimum by their introduction into steam machinery. The gentlemen of this persuasion may be divided into two classes. The first is composed of men who never made or used a steam-engine in their lives, and probably never will—of pure theorists, in fact. The second is composed of mechanical engineers who make engines to sell. We do not use the words "to sell" in the invidious sense, but we can find no other phrase which so clearly defines the difference between the manufacturing engineer and the manufacturer, or steamship owner, who does not make but use steam-engines. Now, within certain limits, and under certain conditions, it is true that any steam engine using less fuel than any other engine of the same power, will be the best; but the advocates of extreme economy in the matter of fuel totally forget that there are conditions and circumstances which may render the employment of excessively economical engines, so far as fuel is concerned, excessively uneconomical in the long run. Those of our readers who are discriminating employers of steam power, and possess experience as manufacturers, or steamship owners, will have little difficulty in recognizing and defining these conditions; but it is, we think, worth while to say something on the subject for the possible benefit of those—either makers or owners of steam power—who know little of the true daily life of an engine.

It is generally understood that an engine consisting essentially of a cylinder and piston, crank and fly-wheel, slide-valve and condenser, Cornish boiler and furnace, and little else, will not get the greatest possible indicated power out of a given quantity of coal burned. It is possible, however, to get a horse-power per hour with a very simple condensing engine, from the combustion of 4 lbs. of good coal per hour. If we want to get more power from the same or a smaller consumption of fuel, we must introduce certain mechanical expedients specially intended to economize fuel. Thus, for example, we must have a separate expansion valve or its equivalent, a steam jacket, a high speed of piston, a very efficient condenser, a superheater, etc.; in return for which the consumption of steam, and, of course, of fuel, will be reduced. Some of these select mechanical expedients may be applied without necessarily risking the permanent efficiency of the machine; others cannot. And it is a very important point to decide which of them can be introduced with propriety under given conditions,

* See page 378.

and which cannot. In dealing with this question a broad principle may be laid down, which is that the multiplication of static steam economizers is never objectionable, superheaters excepted; while the multiplication of dynamic economizers is to be deprecated, or permitted only after due consideration has been paid to the nature of the work the engine has to do, and the qualifications of the men into whose hands it will fall. It will be proper here to define what we we mean by a static and what by a dynamic steam or fuel economizer. We cannot do this better than by giving an example. A steam jacket to a cylinder is a static steam economizer. It has no working parts, does not move, and, if properly made at first, will never cost one farthing for repairs or renewal. A dynamic economizer is, on the contrary, an expansion valve, a second piston, a peculiar air-pump—any moving part, in a word, which tends to increase the economical efficiency of a steam-engine.

It so happens that statical improvements are invariably productive of good, and should therefore in all cases be freely adopted. Their first cost, too, is comparatively moderate, and once supplied and paid for, we know that they need not cost another fraction. Unfortunately, the contrary is the truth, whatever may be said of so-called improvements of the dynamic character. At a very moderate additional outlay, all cylinders may be cast with a steam jacket, which will last as long as any part of the engine without costing a farthing for repairs, or endangering the good working of the machine for a moment. But of how few dynamical improvements can as much be said? The sole objection to the jacket lies in the fact that because its use causes the engine to work with dry steam, the cylinder may be cut up. With a very ordinary amount of attention no trouble will be experienced in this way; and should a cylinder face show signs of getting out of order, we have only to turn a tap, shut the steam out of the jacket, and wait a few days till the cylinder comes to a face again; which it will do if of good metal, and not allowed to get into very bad order. Again, improvements in the design or setting of boilers, in the proportioning of the area of steam-pipes and passages, and such like, may be all classed as statical improvements, and should be freely adopted under all conceivable circumstances, except in districts where coal can be had at nominal rates.

If we turn to the most economical engines, so called because they burn little coal, we find that in addition to—or very frequently instead of—statical improvements, we have a great number of dynamical improvements. In other words, there is a multiplication of moving parts, often accompanied by bad design, bearing surfaces deficient in area, and a general lack of strength in the parts, and of fitness to the intended purpose. Such engines never give as much satisfaction as would machines far plainer and simpler; and it is especially noteworthy that these complex engines are, after all, even in the matter of coal, often only apparently more economical than simpler engines. Th[illegible] can maintain that a compound steam engine with a high and low pressure cylinder, two or three sets of slide and expansion valves, two sets of stuffing-boxes, etc., will work with as little internal friction as a single-cylinder engine of the same power and equally well made; yet the indicated power of the two engines may be identically the same, in which case the compound engine is doing less paying work than its rival; or the indicated power of the compound engine may be greater than that of the single-cylinder engine, though its useful work is not. This point is frequently overlooked, but it is one of considerable importance when we come to estimate the relative economical values of engines in decimals of a pound of fuel per horse per hour.

It is possible, we believe, in practice, to obtain a horse-power, indicated, from the consumption of a little over 22 lbs. of steam per horse-power per hour. But the engine which will do this ceases to be a practical machine, and becomes little more than a huge scientific toy. That it can be worked for a time with success in good hands no one will dispute, but in the long run no such complicated combination of cylinders, steam heaters, etc., etc., can prove generally satisfactory. The experience of Cornish engineers with excessively simple engines, is conclusive in showing that the engines which burn least coal in doing a given amount of pumping are not the most economical in the long run; and we have not the slightest doubt that if fuel and repair accounts were properly

kept elsewhere the conclusions of the Cornishmen would be freely endorsed by others. In all so-called improved economical engines with which we are acquainted there is a superfluity of what we must term trifling details—trifling, that is to say, in strength and dimensions, yet essential to the good working of the machine. The failure of any one of these may do infinite mischief. If we speak to the maker of such engines, and remark that such and such a detail appears likely to get out of order, the answer is, "Suppose it does, you stop your engine for an hour and replace it for 5s.—that is all." These gentlemen forget that to stop the engine driving a large factory is like stopping a man's heart. It is worth while to fix this fact—the evil results of a failure even in slight details—on the minds of our more youthful readers by citing a case in point. Last week we stood in a rolling mill in full swing. The engine, a very simple horizontal one, had just been started to roll off a heat with which two large furnaces were charged. Almost while the first bar was in the rolls, the brass spindle of the screw starting valve broke. The valve went down on its seat, the engine stopped, and nothing was left to be done but draw the piles from the furnaces and leave them to cool. Two hours were occupied in replacing the broken spindle. The cost of replacement was possibly 5s., but what was the loss caused by an entire mill standing still for two hours? What was the loss in fuel and iron? A hundred times the cost of replacing the broken spindle would not have paid the damage caused by its failure. Would not any man be insane who, to save a little fuel, adventured on the use of an engine constantly open to such casualties? Would it not be better to put down a good, plain, substantial engine, reasonably economical, on which he might pin his faith as certain to be always ready when wanted for years, even though it did burn a little more coal?

Another point to be considered in putting down a complex engine is this: If the engine is run constantly day and night throughout the year, as hundreds of engines are, sooner or later it will get out of repair in little things. Some of its many joints will begin to leak; some of its valves too want facing up; someof its parts will get out of line, and it will generally fall off in accuracy of performance. There is no time for a comple'e repair, and so it goes on as best it can; the immediate result of its defects being that its efficiency falls down at once to the level of that of a very ordinary type of engine indeed. We have then all the first cost, friction, and risk attending the use of a complex engine, and no counterbalancing advantage. We do not wish to be misunderstood. We believe that, under certain circumstances and conditions, it is advisable to pay a long price for an engine which shall be eminently economical in fuel, but we also hold that such conditions are more frequently absent than present. When an engine has but ten or twelve hours to work out of the twenty-four, when it is lightly loaded, when it is placed in the hands of first-rate attendants, and where coal is very dear, the introduction of a great deal of complication may be permissible. But in all the thousands of cases where an engine is heavily loaded, continuously worked, and when its continuous working is essential to the prosperity of the concern, dynamical appliances intended to save steam should be introduced with the utmost caution.

THE PRUSSIAN IRON TRADE.—The Prussian iron trade shows much activity; the demand for pig has, indeed, acquired such proportions that the blast furnaces can scarcely keep pace with the consumption. In consequence of an advance in the price of coke, and in consequence also of the diminished imports of English pig, the Prussian firms have raised their prices to some extent. There has been a good demand for merchants' iron upon the Prussian markets, and prices have advanced. Large orders for rails have been given out, as much as 37,500 tons being required for State lines in Northern Germany, and 12,500 tons for Southern Germany; the rail-rolling mills of Prussia will be fully employed for the whole year in the execution of these and other orders.—*Engineering.*

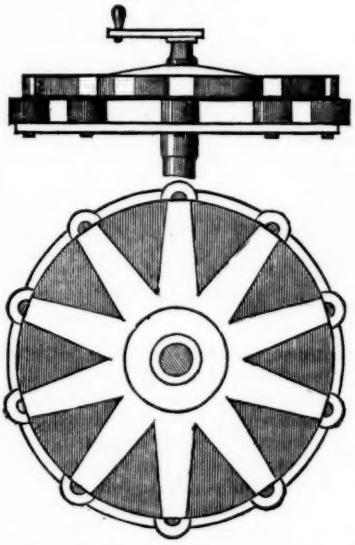
THE "London Times" is now printed on a new press of novel pattern, invented by Mr. Walter. It turns out 11,000 impressions, printed on both sides, in one hour. The Hoe press, heretofore the best, turns out but 7,000 impressions an hour.

SUBMARINE WARFARE*.

From "Engineering."

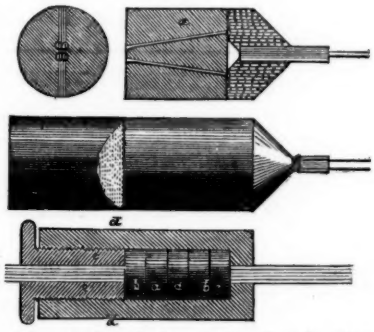
This is a truly excellent book, the result of much labor and research, the record of the most important advances that have been made in the development of submarine warfare, and the description of the principal experiments that have been made with defensive and offensive torpedoes that have been conducted on the other side of the Atlantic.

FIGS. 1, 2.



Tracing the history of submarine explosives from their commencement, the author attributes to an American, the first practical experiments in destroying ships by the application to their sides below the water-line, of sumerged powder-charges, and traces the subsequent labors of Robert Fulton in France, England, and America. Sketching the gradual advancement of the new branch of military science up to the date of and through the Russian war, the author passes on to the consideration of the numerous devices, generally so effectual, which marked characteristically the American civil war, and which, at first condemned as weapons unworthy of a civilized nation, became at last recognized as legitimate means of offence and defence. During that prolonged conflict, the ever-increasing difficulties of the Southern army, and their straitened means, drove them to the adoption of torpedoes to a much greater extent than their antagonists, whose marine suffered to a terrible extent. After the termination of the war, the mutual experience became available, supplied

FIGS. 3, 4.



on the one hand from the South, whose ingenuity had schemed the means of destruction, and by the North on the other, whose ships had been annihilated, and whom necessity had taught how best to avoid the unseen dangers which had beset the river and the seaboard, during the season of hostilities, as well as how to seek for and render harmless the set torpedoes, and how to destroy submarine obstructions.

We need not further allude in this place to the various designs of the torpedoes used during that time, because we shall publish shortly drawings of the principal forms, but will pass on to the latter portion of Commander Barnes's book, treating on electric torpedoes, submarine guns, and obstruction destroyers.

Although Fulton had conceived the possibility of employing electricity as a means for exploding torpedoes at will, and the Royal George had been partially destroyed in 1839 by that means, the

* "Submarine Warfare, Offensive and Defensive, including a Discussion of the Offensive Torpedo System; its effects upon Ironclad Ship Systems, and Influence upon Future Naval Wars." By Lieutenant-Commander J. S. Barnes, U. S. N. New York: D. Van Nostrand. London: E. & F. N. Spon, Charing-cross.

Russians were the first to systematize this system in its application to harbor defences, without, however, producing any effective result. Before 1851, Austrian engineers had employed this agent for the purpose of igniting charges, and with great success, experimentally, in conjunction with Colonel Scholl's fuse, an arrangement consisting of a wooden bar, terminating in a wooden cone, hollow, and containing an igniting charge of gun-cotton, which is in contact with the wires of the battery. These wires, passing through the cone, lie within grooves cut into the sides of the fuse for its whole length, and convey the spark through the gun-cotton, by which the latter is ignited. When a copper wire has been covered for some time with vulcanized gutta-percha, the interior of the tube, on withdrawing the wire, remains covered with a thin layer of sulphide of copper, which is a moderately good conductor of electricity. If a section of the tube thus formed be interposed between the ends of the conducting wires, and a current of sufficient intensity be caused to circulate through the wire, it will leave the wire at the break, and pass through the sulphide of copper; but here sufficient resistance will be met to ignite the sulphide, and, if it is in contact with gun-powder, will explode it. Upon this principle a fuse, much used during the Russian war, was employed. The ends of the copper wire are separated by .15 in., and placed within a gutta-percha tube, one side of which has

Fig. 5.

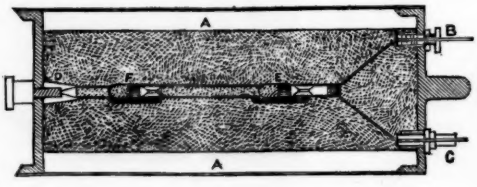
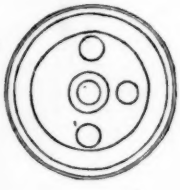


Fig. 6.



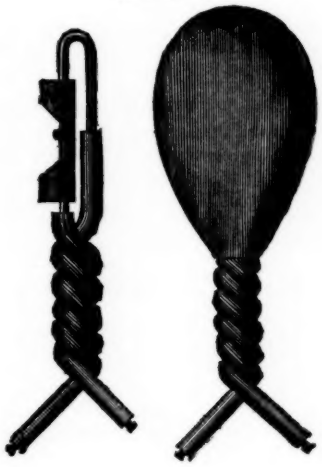
been partly cut away to bring it into direct contact with the priming powder. (Figs. 7, 8.) The space between the ends of the wire is filled with fulminate, which is ignited just as is the gun-cotton in Colonel Scholl's arrangement. In the same manner platina wire connecting the terminals of the conductors is found effective. Experiment has shown that the best results are obtained from a wire $\frac{4}{10}$ths of an in. long and $\frac{4}{1000}$th of an in. in diameter. By this arrangement powder can be ignited throuph the aid of a single element of the Bunsen battery at a distance of 155 yards.

Following the description of the various European torpedo magnetic exploders which are tolerably familiar to us, such as Verdu's, Breguet's, and Wheatstone's, the author passes on to the consideration of the best instruments which have been devised in the States for this work, and of which the one most in favor is that designed by Mr. G. W. Beardslee, of New York, an instrument like the Wheatstone exploder, but differing from it in mechanism and the arrangement of the magnets, by which it is claimed that a larger quantity, though a less intense current, is obtained than by the Wheatstone instrument. The Beardslee exploder is a radial magnet, with ten poles built up of cast-iron plates, collectively 1 in. thick, and measuring 15 in. from point to point, which are negative and positive poles alternately. The spaces between the arms are filled with wood, and the whole instrument is caused to rotate rapidly by gearing. The magnet is placed upon ten soft-iron cylinders, covered with fine silk-covered copper wire, 440 yards of which are coiled upon each of them. The ends of the coils are joined together, so that a continuous current can pass round any number of the cylinders, which can be arranged in sets according to the intensity required, or if quantity be the object, the coils are separated and each coil throws its current into a common conductor. (Figs. 1, 2.) In connection with this exploder is a fuse by the same inventor, which found great favor in the United States, and which is remarkable for its simplicity and certainty of action. Into a hard wood cylinder are driven two copper nails, converging, yet not in contact at the points, which are driven through

the wood. Connected with the heads of these nails are two insulated wires, and across the points of the copper conductors a groove is filed, and plumbago being rubbed within the grooves, the circuit from wire to wire is completed. A soft lead pencil drawn across the groove answers the purpose well, and a small charge of powder placed in connection with the plug completes the fuse. (Fig. 3.)

Two others of Mr. Beardslee's inventions may also be noted—a torpedo, of which the construction is shown in the accompanying sketch, and a union joint for coupling conducting wires. (Fig. 4.) In the latter the two strands of wire to be joined pass through two discs of metal, *a*, *a*, and two of hard rubber *b*, *b*, the whole being enclosed in a gutta-percha tube. The wires of each strand being separated radially, are spread over the face of each disc, and a metal washer, *c*, is placed at the bottom of the tube, the whole being kept tight by a screw plug of gutta-percha. In the torpedo, see Figs. 5 and 6, the case is made of galvanized iron, with cast-iron ends. The conducting wire passes through an india-rubber union at B, into the centre of the torpedo, and being fastened to the bottom of the machine, is connected to the ground wire, which returns through the torpedo, and passes out at the end by a brass union at C, the fuses being connected to the wires, as shown. The powder charge is contained within an inner chamber, surrounded by an air chamber. The value of the addition of an air chamber to torpedoes has given rise to long discussion, and considerable experiment in the States. The shell with an air space, designed by Messrs. W. W. Wood and Lay, of the United States Navy, in 1864, was afterwards advocated and adopted by Mr. Ericsson in the obstruction remover constructed by him, and the advantages claimed for the air chamber are, briefly, the power of directing and concentrating the force of an explosion, a buoyancy by means of which the shell is more easily managed, and its position better maintained, and a certainty that the entire charge can be consumed before the water can enter the casing and destroy the explosive. In a number of experiments conducted with torpedoes made on this principle, and loaded with charges varying from 40 to 60 lbs. of powder, the results obtained were so much in excess of what had been produced by the explosion of ordinary torpedoes with similar charges, that the advantages claimed by the inventors were apparently established.

FIGS. 7, 8.



From a series of experiments, however, carried on at Willet's Point in 1865 by Major W. R. King, it is argued that the advantages of an air chamber, as claimed by Messrs. W. W. Wood and Lay, were much exaggerated. In the conclusions deduced from the experiments Major King says: "The results of the first series of trials indicate that an air chamber should not be interposed between the charge and the object to be destroyed. It is as easy to place the charge near the object as to place an air chamber there, and, in addition to the increased effect of the former arrangement, we have, by placing the air chamber below the charge, an additional security against moisture reaching the powder." We must confess, however, that the evidence based upon experiment, and brought forward in favor of, or against, the air chamber, is very limited, and insufficient to deduce any absolute conclusion. We shall, however, take an early opportunity of again referring to Major King's experiments, which are extremely interesting and useful.

In concluding our notice of this book, we must congratulate the author upon having excellently executed his task. He has put forth a volume alike interesting

to the professional and the casual reader, for the story of the submarine war of the United States is full of lively and unflagging interest, while the whole book must be regarded as an American torpedo manual, containing valuable information. Lieutenant Barnes has spared no labor to perfect this work, and has wrought upon it with the pen of an able and fluent writer.

RAIL TESTS ON THE NEW YORK CENTRAL.

From "The American Railway Times."

MR. EDITOR,—I herewith hand a statement of tests recently made at West Albany, by the permission of Vice-President Torrance. Under the management of this gentleman, rail tests have become an institution on the New York Central, and the importance of these tests is best demonstrated by the fact, that since their introduction the rail section of that road has been changed from 4 in. height to 4½ in. for steel rails, and to 5 in. for iron rails. The tests herewith stated are made with rail pieces four feet long, all of similar section, and with exception of No. 1 and 2, 4½ in. high.

In comparing the tests, it must therefore be remembered that the 5 in. No. 1 and 2 rails should (theoretically) have

Rail Tests at the New York Central Machine Shops, West Albany, in presence of G. B. Van Voast, M. M. F. Roth, Alex. Elbers. Test by 2,240 lbs. drop. Bearings 3 ft. apart. Temperature 16 deg. Fahrenheit. Commencing at 1 foot drop; deflection in inches.

Number.		DROP IN FEET.										
		1	2	3	4	5	6	7	8	9	10	
1	Rail 5 ins. high, 69⅗ lbs.—Syracuse, deflection	1-8	5-8	1 3-8	2 1-4	broke.						
2	Rail 5 ins. high, 69⅗ lbs.—Rome	3-16	5-8	1 3-16	2	3 1-16	4 3-8	6	broke.			
3	Rail 4¼ ins. high—Syracuse	1-8	9-16	1 1-4	2 1-4	3 5-8	5 1-4	broke.				
4	Rail 4¼ ins. high—Funcke & Elbers' puddled steel, with iron flanges	1-8	5-8	1 1-4	2 1-8	3 3-8	5 1-16	6 7-8	7 7-8	11 3-8	broke.	At 9th blow flange broke.
5	Rail 4¼ ins. high—Funcke & Elbers' quality-iron rail	3-16	5-8	1 1-4	2 3-16	3 7-16	5	7	.....	broke.	.....	At 8th blow head broke sideways.
6	Rail 4¼ ins. high—Petin Gaudet Bessemer steel	1-16	3-8	3-4	1 1-4	1 3-4	2 1-2	3 5-16	.....	broke	.....	in 3 pieces. At 8th blow broke both flanges at the bearings.
7	Rail 4⅛ ins. high—Manchester Bessemer, marked "section 27".	1-8	1-2	7-8	broke.							
8	Rail 4¼ ins. high—Funcke & Elbers' full-steel rail	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Broke at 1st blow at 15 ft. elevation of drop.
9	Rail 4⅛ ins. high—Petin Gaudet Bessemer rail	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Broke at 1st blow at 10 ft elevation of drop.

about 22¾ per cent. more strength or resistance against rupture, than the 4½ in. rails, and about 40 per cent. more strength than 4 in. rails. Judging from appearance of fracture, the No. 1 and 2 rails were made of cold-short re-rolled iron; No. 3 rail—fibrous base and part of head fibrous, and No. 5, "quality iron," hammered, vertically piled, cold-short head, base and steam fibrous and fine-grained.

The poor result of No. 7 test I consider an exception, as it is well known that Bessemer rails, of almost any make, will, in the average, show good results under the drop-test. The only remarkable result is, that the No. 6 and No. 12 Bessemer rails,

after showing great toughness, broke finally into three pieces, *which no good iron rail* can be made to do under similar circumstances.

Though rail-tests by heavy drops are very instructive (especially when the temperature at the time of testing is taken into account), and answer the purpose of testing the quality of iron rails and *welded* steel rails, I think that they are of little value for determining the practical strength of Bessemer or cast-steel ingot rails, which are much more affected by *vibration* than the former—*i. e.*, a rail piece under the drop is *inert* until the drop strikes it, whereas rails in the track (especially when fish-jointed, *are in violent vibration long before the approaching train passes over them.*

It is well known that ingot rails have been broken in the track into three pieces, when their outside as well as the fracture surfaces appeared entirely free from flaws or other defects. These broken pieces could subsequently not be broken under a 1 ton drop at 20 ft. elevation.

Question: Can ingot rails—which, on account of improper heating, retain an inner tension or unequal strain, after being rolled out and cooled—*break* merely on account of vibration? Similar results occur occasionally with cast bells.

ALEXANDER ELBERS.

WEST ALBANY LOCOMOTIVE DEPARTMENT, *February* 7, 1870.

Test of Rails by 2,240 *lbs. drop. Bearings* 3 *feet apart. Signed F. J. Roth.*
Temperature, 3.30 *P. M.,* 64 *deg. Fahrenheit. Commencing at elevation of* 1 *foot.*

Number.		DROP IN FEET.											
		1	2	3	4		6	7	8	9	10	11	
12	4½ ins. Dowlais, 12, 1869. Guest's steel, 67¾ lbs, New York Central standard section	1-8	9-16	1-8	1 3-4	2 7-16	3 5-16	4 3-8	5 11-16	7 1-16	7 3-4	broke.	(in 3 pieces. At 10th blow bent sideways.

Commencing at 10 *ft. Drop.*

Number.		DROP IN FEET.					
		10	11	12	13	14	
10	4½ ins. Funcke & Elbers' 66 4-10 lbs. puddled steel rail, foot and part of stem fibrous iron, deflection.....	3 1-4	6 7-8	10 1-2	broke.		
11	Funcke & Elbers', all steel, 66 8-10 lbs...	2 3-8	4 7-8	12	17	broke.	(At 13 feet drop bent partly sideways showing small fractures; bent at right angles; had to be turned to break it.

RAILWAYS OF THE COLONY OF VICTORIA.—A return of the revenue and expenditure of the Victorian Railways for the half year ending the 30th of June, has been laid before Parliament by the Commissioner of Railways. The total train mileage is set down at 549,969 miles. The expenditure was £116,759 6s. 1d., including as items, £22,016 for maintenance of permanent way and works, £39,771 for locomotive charges, £47,146 for traffic charges, and £6,725 for general charges. The revenue during the same half year is stated at £279,117 17s. 11d.; of this, £114,060 was made up of the following items: Passengers (497,335½), £100,049; parcels, £5,592; horses, carriages, and dogs, £2,235; mails, £3,091; rents, £2,441, and gold escort, £650. The remaining £165,057 was made up of other items, such as goods (202,300 tons), £155,307; live stock (17,309), £9,749. A balance of £162,358 11s. 10d. was left in favor of the revenue.—*Engineering.*

INTERNATIONAL COMMUNICATION.

From "Engineering."

In the midst of all the numerous schemes, more or less chimerical, for meeting that requirement now allowed on all sides to be an absolute necessity, the proposition of Mr. John Fowler, Mr. Abernethy, and Mr. Wilson, has gradually taken a more and more prominent position, until it is recognized as the one means whereby the present inconvenience attending the Channel transit may be avoided, at all events, until the advancement of engineering skill and enterprise has pointed out a more efficient way, and proved by actual construction all that may be claimed for it, and which shall supersede the large boats, and ample accommodation Mr. Fowler provides, by accommodation more ample and transit more convenient and more rapid. Such schemes, despite the fact that some of them have been considered and advocated by engineers as able and responsible as those connected with the Channel ferry, must needs give precedence to that of Mr. Fowler. There is nothing problematical about his proposition, nothing uncertain. The difficulties to be encountered are on the surface, they can be accurately estimated and provided against, and the only element of doubt is the degree of commercial success which will ultimately attend the enterprise.

But although the opinion of efficient engineers, even of those who have put forward less certain, if bolder schemes, substantiate the views taken by the promoters of the channel ferry scheme, a number of incompetent objectors exist, whose adverse opinions possess sufficient weight to create much prejudice against the project. Nearly all the objections urged by this class of persons are comprised in a letter, which recently appeared in a daily paper, from a representative of these non-competents, and displays that lack of knowledge upon the details of the scheme he professes to criticise, which amply accounts for the errors into which the writer has fallen.

It is urged that, because the Great Eastern has proved unprofitable as a passenger ship, therefore large ferry boats plying between the English and French coasts must be also commercial failures; that the top weight produced by the presence of a train of carriages on deck would inevitably cause excessive rolling; that the difference of gauge between the French and English railways would prevent the interchange and working of stock on both sides of the Channel; that the harbor site selected on the French side is 8 miles removed from railway communication; and that, besides the want of judgment shown in selecting such a point as Andrescelles for the French terminus, the vast cost of making the harbor, assuredly much underestimated by the engineers, and the time required for their construction, would fatally interfere with the prospects of such an undertaking as a Channel ferry. Such, in brief, are the chief objections urged against this scheme, easily answered, but the impression produced by which it is not easy to remove.

It is difficult to understand why, because a sea-going ship, of upwards of 20,000 tons burthen, proved a failure as a passenger ship working 3,000-mile journeys, a ferry boat of 7,000 tons should necessarily work unprofitably upon a course of 20 miles with a constant stream of traffic flowing to and fro. As absurd is the argument, that the weight of the carriages on deck will induce rolling. Those objectors who so freely illustrate their case by quoting the Great Eastern, appear unable to realize the fact that the weight of 120 tons on the deck of a boat of 7,000 tons capacity would produce no appreciable result. In their mind's eye the deck of such a vessel appears crowded with railway carriages (to the exclusion of space for other accommodation), which would fearfully hamper the ship and inconvenience the passengers; instead of which the width of such a train would not be one quarter that of the boat. With regard to the alleged difference of gauge urged as existing upon English and French lines, it may be sufficient to state that both railways are of the same width precisely.

It is somewhat bold to challenge the judgment of three able engineers, by whom Andrescelles has been selected as the most suitable spot for a French landing place, and also to throw discredit upon

the estimates which have been carefully worked out and revised during the past few years. Besides the natural advantages offered by Andrescelles as a harbor, and they are great, its position with regard to Paris, will, when the few miles of railway are made that will connect the port with the main line, give those passengers who select the Dover and Calais route a considerable advantage in respect to time and distance, without materially interfering with the routes to the north of France and Belgium.

To all who are really able to appreciate the requirements for working the Channel traffic, it is apparent that it can (at present, at least) be only effected as proposed by Mr. Fowler, and, though the expense of constructing the necessary harbors on both sides will be great, and a considerable delay must be incurred before the new route can be opened to the public, it is at least gratifying to know that this means of international communication has emerged from the vague region of mere projects, and developed into an undertaking of which the foundation is now securely laid.

INDIAN FIELD ARTILLERY.

From "Engineering."

The special committee appointed to investigate the question of field artillery, has recently issued its report, which recommends material alteration in the equipment of that branch of the Indian service. The first great change recommended is the substitution of muzzle-loading rifle guns for the Armstrong breech-loaders. These latter, efficient and reliable, as a long experience has proved them to be, have also been proved by the same experience to be too complicated in their arrangement for easy manipulation in practice, and the resolution of the committee recommending the return to muzzle loaders will meet with general favor throughout the artillery service, which was largely represented by witnesses examined by the committee, and who were unanimous in giving their opinion that, under all circumstances, it was desirable to introduce muzzle-loading field guns into the Indian service.

In material, also, an important alteration has been suggested for adoption, and, despite the well-known reliability of iron, and the numerous objections raised against the use of bronze, such as its deficiency in durability, its softness, and its liability to rapid scoring, deterioration, and even melting under a rapid and sustained fire, bronze has been recommended by the committee as the material to be adopted in the future construction of light artillery.

This conclusion was not arrived at without a due consideration of the objections urged against the advocates of iron and steel, and an exhaustive series of trials were carried out to prove how far bronze could be relied upon, and the result of these experiments has fully justified the committee in their resolution.

The question of durability was decided by firing from two experimental guns, in one case 2,673 and in another 1,362 rounds without failure, a test "equivalent to a duration of about fifty-three and twenty-seven years of ordinary service," respectively. The capability of the metal to resist the effect of rapid firing was then proved by a rapid succession of 50 and 140 rounds at the rate of some 3 rounds per minute, and the other objections urged, such as rapid scoring, wearing away of the grooves, and honeycombing of the metal, were likewise answered by these and other tests, and it was shown with tolerable certainty that although undoubtedly there was a considerable wear of the grooves, it was confined to the loading sides, and not to the bearing sides of the grooves.

Altogether four classes of bronze guns were experimented upon by the committee, each of them 9-pounders, with 3 grooves, the twist of which was 1 in 30 diameters, the depth 11 in., and the width 8 in. Two weights, 6 cwt. and 8 cwt., were employed, and two classes of rifling, the Woolwich system, and an adaptation of the French plan, which last was ultimately recommended in conjunction with the heavier piece, which gave better results, in accuracy, extent of range, and could also, if necessity demanded, be employed as a 12-pounder.

The ammunition recommended for this

new weapon consists of common shell, case shot, and shrapnel, provided with Boxer's wood time fuses, set to nine and five seconds. An efficient percussion fuse is also recommended, if such can be designed; in which case the proportion of different projectiles would be considerably altered. At present, segment shell, it is suggested, should form no part of the equipment, which should consist of more than one-half shrapnel. A charge of 1 lb. 12 oz. is recommended, and a bursting charge of 7½ oz. for the common shell.

Wrought-iron carriages have been recommended for every reason, in preference to steel or wooden ones, and the experimental carriages employed by the committee have withstood a test of 3,746 rounds in one case, and 3,360 rounds in the other, with but small injuries. Important modifications have been introduced into the pattern of carriage suggested, by which the gunners, working the battery, can be brought up with their guns; the ammunition boxes have been re-arranged, and the elevating screw has been designed in the simplest possible manner, and consists of a screw passing through a nut upon brackets on the carriage, and driven by gearing and a handle outside the bracket.

Important improvements have also been made in the design of the wagons attached to the battery.

The following are the particulars of dimensions and weight of the new guns and wagons;

Nine-pounder Gun, 3 in. Bore, French Rifling.

	cwt. qts. lbs.	
Actual weight	8 0 12	
Breach preponderance	.....	7 lb.
Bore { Diameter	.....	3 in.
Bore { Length	.....	63.5 in
Grooves { Number	.....	3
Grooves { Width	.....	11 in. at top, 8 in. at bottom
Twist uniform,	one turn in	90 in.
Length of rifling	.....	59.8 in.
" gun over all	.....	72.0 in.
Weight of gun carriage	10 2 0	
" limber	10 0 0	
" ammunition and stores	4 0 9	
Total weight	32 2 12	

The total weight of wagon will be 32¾ cwt., including 90 rounds of ammunition. This number, together with that carried on the gun itself, increases the total number of rounds per battery to 124.

WHEELER'S STEEL-IRON PROCESS.

From "The United States Railroad and Mining Register."

Notwithstanding the great progress made of late years in the cheap production of steel, and the consequent largely increased use of this material, it is a fact not to be controverted that steel alone does not, and cannot fulfil all the conditions which are inevitably imposed upon any material subjected to the almost universal applications required by our great mechanical and railroad interests.

This failure is not due to the steel itself, but rather, we think, to a misapplication of it—to placing it in a position for which it is not adapted by nature, and, as it were, forcing it to do work, and to bear load and strain, for which it was never intended.

"The conclusion at which I have long since arrived," says Sir Wm. Armstrong, "and which I still maintain, is, that although steel has much greater tensile strength than wrought-iron, it is less adapted to resist concussive strain. * * * It is impossible that I can hold any other opinion than that the vibratory action attending accessive concussion is more dangerous to steel than to iron."

Here then is the rock on which the too enthusiastic advocates of steel have fallen. Because steel could be produced cheaply, they have endeavored to supplant iron with it, overlooking, for the time, the fact that steel could not be both steel and iron; and, therefore, it should not have been subjected to conditions which required for success that it should possess the desirable qualities of each.

Experience is a good teacher, but charges abominably high prices, says Carlyle, and though the disappointment of steel makers and of steel users has been attended with no little expense, the

experience gained has been valuable, and is leading in a direction where we shall be able to secure and render available the well-known desirable properties of steel, without incurring the dangers of its treachery when employed alone.

For some time the attention of practical men has been attracted to the great desirability of so combining large masses of iron and steel, as to secure the tenacity of the one with the durability of the other. Every mechanic is familiar with combined iron and steel and its constant and successful use where steel alone will not stand at all; but the difficulty in thoroughly uniting two such dissimilar metals, involving the use of expensive fluxes, hand labor, and the most skilful manipulation, has hitherto precluded its use except for special purposes, and has, therefore, made its cost double and treble that of all steel.

The numerous attempts that have been made to make a steel-headed iron rail, show conclusively the desire of our railroads to secure the two important elements of strength and wear; but the difficulty in attaining this desideratum has been the impracticability of uniformly securing such a union of iron and steel as would stand the tremendous tests of weight and speed, and also to make the union so cheaply as to afford the rail at a reasonable price.

Every blacksmith knows full well the danger of "burning" steel when heating it to a welding point, and this risk is immensely increased when the mass is augmented as for a "rail pile," and subjected to the intense heat of a furnace; if fluxes and steam-hammers are employed to perfect a union of "high" steel and iron, the cost of the operation is too much enhanced to be remunerative, while, an the other hand, if "low" steel, which will stand heat, is used, the resulting rail head is scarcely, if any, better than iron.

These apparently insurmountable obstacles have thus far been the one great difficulty in the way of successfully and cheaply combining iron and steel in such masses and proportions as would make the combination available for such extended purposes as are required by the great railroad and mechanical interests; but it is too much to say, in this age, that a thing cannot be done because previous attempts have failed, and we often find that means the most simple, and overlooked because of their simplicity, are amply adequate to produce a long-desired result.

We have within a few days seen and examined a process for uniting iron and steel, discovered by Mr. E. Wheeler, of Philadelphia (late of Boston), which, from its extreme simplicity and certainty, seems to fill all the conditions for working the two metals into successful combinations for any and all purposes. Mr. Wheeler has for many years been a practical iron manipulator, and has for some time been engaged in extensive experiments to combine iron and steel. Starting with the theory that there is no difficulty in uniting the two, providing that the steel is brought to a "welding heat" simultaneously with the iron, and that the steel, while being so heated, cannot suffer injury or "burning," if kept from the direct action of the flame and oxygen (as when melted in a crucible), he reduces it to practice by the ingenious and simple device of completely encasing the steel with iron during the entire process of heating and reduction. The steel being thus not merely covered, but encased, is effectually protected from the decarbonizing effects of excessive heat, and can be safely heated to a perfect welding state in the usual iron furnaces without flux of any kind, and in this condition may be rolled down and manipulated as readily, and at the same speed, as iron, in ordinary rolls.

Simple as this method is (and its simplicity is its great value), it accomplishes the most important results. We have seen the highest grade of cast tool steel, thus enclosed, and filled with iron, subjected to the intense heat of a heating furnace, and then rolled down into bars at the rate of 500 ft. per minute, and the steel, though perfectly welded to the iron, presented the same bright, clean fracture when broken as in the original state, and would harden as readily in a water bath.

Mr. Wheeler showed us a car axle rolled by his process at one heat, at the Pencoyd Works, of this city, consisting of a core of iron surrounded by a tube of steel, and both in turn by a shell of iron, the whole being as solid and perfect as a homogeneous mass of iron. This plan gives a steel journal, while the iron core and shell secures strength and prevents fracture or breakage of the steel.

The practical uses to which this cheap and effectual method of welding iron and steel can be applied are innumerable. By it any grade or kind of steel may be used, from Bessemer or "puddled" to crucible, and it can be united to iron in any shape or proportion. Mr. W. is already making combination in merchant bar forms, at the works of Messrs. Marshall, Phillips & Co., 24 Girard avenue, Philadelphia, for set screws with steel centre, horse-shoe bars with steel face, carriage tire with steel corners, etc., etc., and we learn that several prominent rail manufacturers are about to apply this process to the making of steel-headed rails, for which it appears peculiarly adapted.

Another very important application of the invention is to the reduction of steel ingots and the reworking of steel bars or scrap. Hitherto immense steam-hammers have been found indispensable to condense the ingot, or compact the pile, and make the steel homogeneous and sound, from the fact that, owing to the impracticability of heating exposed steel above a "cherry red" without injury, only immense force could compress the particles, and render the mass uniform. By Mr. W.'s method of encasing the ingot or pile in iron, he makes heat do the work of applied force, and by thus safely heating the steel to a soft state is enabled to condense and compact it with a comparatively slight expenditure of power by means of ordinary rolls.

TUNNELS OF THE PACIFIC RAILROAD.

Abstract of a Paper read before the American Society of Engineers, Jan. 5, 1870, by JOHN R. GILLISS, Civil Engineer, Member of the Society.

During the past summer the track has been completed across this continent, and so much sooner than was thought possible, that the difficulties overcome are apt to be underrated. Some account of a single item in the great work may therefore be interesting.

Between Omaha and Sacramento there are nineteen tunnels. Four of these are on the Union Pacific and fifteen on the Central.

Central Pacific Tunnels.—The tunnels of the Central Pacific are nearly all near the summit, where it crosses the western range of the Sierra Nevada. The line here lies on steep hill-sides, in some cases being, for long distances, on a face of bare granite, more or less broken by projecting ledges and boulders, but with an average slope often greater than 1 to 1. In such places embankments were almost impracticable; the hills were too steep to catch the slopes, and most of the rock from cuts was thrown far down hill by heavy seam blasts. On these accounts the line, for two miles east of Donner Pass, was thrown further into the hill than on original location, thus adding to the depths of cuttings and increasing the number of tunnels, but saving retaining walls, and where tunnels were made, enabling the work to be carried on in winter. Another important object was the saving of snow-covering where tunnels were made, and giving a good foundation for it where they were not. It is within these two miles that seven tunnels are crowded.

Tunnels 1 and 2 are both west of Cisco, a small track 92 miles from Sacramento, and within 13 of the summit. They were both finished in 1866. During the fall of that year the track reached Cisco, and as fast as the gangs of Chinamen were released they were hurried to the summit to be distributed among the tunnels in its vicinity. The year before, some gangs had been sent to summit tunnel No. 6, and commenced the cuts at its extremities; winter set in before the headings were started, and the work had to be abandoned. To avoid a repetition of such delay, the approaches to all the tunnels were covered with men, and worked night and day in three shifts of eight hours each. Thus time was saved, and the tunnel organization started at once. As an illustration of the hurry, I may mention walking two miles over the hills after dark, and staking out the east end of No. 12 by the light of a bonfire; at 9 o'clock the men were at work.

In November and the early part of December there were several snow-storms, just enough to stimulate without delaying the work. The rough rocky sides of Don-

ner Peak soon became smooth, slopes of snow and ice covering the trail that led from tunnel 8 to 9; it remained impassable until spring, and communication had to be kept up by the wagon-road, five or six hundred feet below. This, the Dutch Flat and Donner Lake wagon road, was opened soon after it was decided to adopt this route. From the Pass the descent toward the lake was over very rough ground, requiring heavy side cuts and retaining walls with numerous zigzags to gain distance.

From this road the scene was strangely beautiful at night. The tall firs, though drooping under their heavy burdens, pointed to the mountains that overhung them, where the fires that lit seven tunnels shone like stars on their snowy sides. The only sound that came down to break the stillness of the winter night was the sharp ring of hammer on steel, or the heavy reports of the blasts.

Winter of 1866–7.—By the time winter had set in fairly the headings were all under ground. The work was then independent of weather, except as storms would block up tunnel entrances, or avalanches sweep over the shanties of the laborers. Before tracing the progress of the work underground, it will be well to see the character of weather out-doors.

A set of meteorological instruments was furnished by Colonel Williamson, of the United States Engineers, consisting of barometer, wet, dry, maximum and minimum thermometers. These, with wind, clouds, etc., were recorded three times a day, and hourly during ten days in each month. From this record the table of storms given in Appendix C was made.

Snow-storms.—These storms, 44 in number, varied in length from a short snow squall to a two-week gale, and in depth from ¼ in. to 10 ft.—none less than the former number being recorded, nor had we occasion to note any greater than the latter. This, the heaviest storm of the winter, began February 18th, at 2 P. M., and snowed steadily until 10 P. M. of the 22d, during which time 6 ft. fell. The supply of raw material was then exhausted, but the barometer kept low and the wind heavy from the south-west for five days more, by which time a fresh supply of damp air came up from the Pacific, and then, as the machinery was still running full speed, this was ground up without delay. It snowed steadily until March 2d, making 10 ft. snow and 13 days' storm. It is true that no snow fell for 5 days, but it drifted so furiously during that time that the snow-tunnel at east end of tunnel No. 6 had to be lengthened 50 ft.

These storms were grand. They always began with a fall in the barometer, and a strong wind from the south-west, hurrying up the tattered rain-clouds or storm-scud in heavy masses. The barometer, which averaged 23 in., would drop sometimes as low as 22½. The thermometer was rarely below 20 deg. at the beginning of a storm, and usually rose to 32 deg. before its close, so that the last snow would be damp and heavy, sometimes ending in rain. The storms ended, and clouds were scattered by cold winds blowing over the eastern range of the Sierra Nevada; these raised the barometer and dropped the temperature at once. The lowest temperature of the winter was from a wind of this sort, 5½ deg. above zero.

Our quarters were at the east end of Donner Pass, but still in the narrow part. About the second or third day of a storm the wind would be a gale, sometimes 10 lbs. to a square foot; and would plough up the new-fallen snow to heap it in huge drifts beyond the east end of the pass. About 30 ft. from our windows was a large warehouse; this was often hidden completely by the furious torrent of almost solid snow that swept through the gorge. On the cliff above, the cedar trees are deeply cut, many branches of the thickness of a man's wrist being taken off entirely by the drifting snow-flakes.

No one can face these storms when they are in earnest. Three of our party came through the pass one evening, walking with the storm—two got in safely. After waiting a while, just as we were starting out to look up the third, he came in exhausted. In a short, straight path, between two walls of rock, he had lost his way and thought his last hour had come.

Snow-tunnels.—Before the snow had acquired depth enough to interfere much with the work, the headings were all started. The cuts at their entrances soon filled up with snow, but drifts were run through them, in some instances large enough for a two-horse team. Through these snow-tunnels, whose lengths varied from 50 to 200 ft., the ma-

terial excavated was hauled in carts or on sleds to the waste banks. These snow-tunnels kept settling at the crown, so that they had to be enlarged from time to time, otherwise they were perfectly satisfactory.

The most remarkable snow-tunnel was made to connect the two ends of tunnel 8. The spur through which this is made terminates in a vertical bluff of granite 100 ft. high. To get around it during the fall, a rope was fastened to the rocks at a point where there was a steep descent of 30 or 40 ft. During the early part of winter, a snow-drift formed on the face of this bluff, descending in a deep slope from its top to the wagon road, 200 ft. below. On this slope a trail was cut and used for a month or two.

Later in the winter, when the accumulation of snow made it practicable, a snow-tunnel was excavated through the drift, and around the face of the bluff. Windows were made at short intervals for light, and to throw the material out in excavating, and steps cut where a descent was necessary. One flight of these led down to the blacksmith's shop, buried still deeper in the snow, while the main passage led into one already excavated at the east end of tunnel 8. The snow kept settling down hill and away from the bluff, so that there was an open space of 3 or 4 ft. between it and the rock towards the close, which was far from inspiring much confidence in the route.

Between tunnels 7 and 8 there is a deep ravine, in crossing which the road has a 4x5-ft. box culvert, and a retaining wall on the lower side at 75 ft. extreme height. The foundation was begun in fall, but stopped by winter, and the ravine filled with snow. Next spring a snow-tunnel was commenced about 200 ft. down the ravine, and run in to strike the unfinished foundation. Smaller tunnels were run to quarry stone got out in fall, and a cave dug over the foundation large enough to work in. The culvert was built, and by the time it was finished the depth of snow overhead had decreased to 25 or 30 ft.; this was excavated by a stream of water, and the retaining wall commenced.

Snow-cuts.—In spring, when the road has begun to be bare, so that sleighs can no longer be used, there are very heavy banks of snow to cut through to make the road passable for wagons.

In June I measured one of these cuts through the end of a snow-slide, and found it 25 ft. deep. A week later the road was dusty in the centre, but the snow-banks were not all gone until July, so that we had at that place the strange spectacle of sprinkling-wagons watering a road between two walls of solid snow

Alignment.—As soon as each heading became sufficiently advanced, the centre line was secured, generally by small holes drilled in the roof, with wooden plugs and tacks. These points were placed as far apart as length excavated would permit, and from them the line produced as the work advanced. In most cases the entrances were afterwards so blocked up with snow that it was impossible to recur to the line outside, and the tunnels were completed from the points first put in.

In running lines outside during the winter, it was generally necessary to make deep cuts, and sometimes tunnels, through the snow, to get at the original transit points.

Most of the tunnels are on curves, No. 13 being on one of 573 ft. radius, with 87 deg. of curvature inside the tunnel. In this, as in No. 11, the usual difficulties of working with instruments by candle-light were much increased by the numerous temporary timbers in the headings. The lines met in the centre of the tunnel, parallel to each other, but 2 in. apart. In the other cases the discrepancies were too slight to notice.

Dimensions.—Most of the work was through solid rock, which did not require lining, and the following dimensions were adopted: Bottom, a rectangle, 16x 11 ft.; arch, a semi-circle, 16 ft. in diameter; grade at centre of tie, and 1 ft. 3 in. above sub-grade.

Tunnel 11 was partly, and tunnel 13 wholly, lined with timber in the following manner: 12″x12″ sills were placed on each side, and posts 12′x16″ mortised into them. The latter support arches, each composed of 3 thicknesses of 5″x12″ plank, breaking joints, and bolted with ¾-in. iron bolts, thus making a solid arch of 180 square in. sectional area. The distance from centre to centre of arches varies from 1½ ft. to 5 ft., according to material. Over the arches, and, where the material required it, on the sides, also, split lagging about 2½ in. thick was put in. The width at sub-grade inside of

posts is 17 ft.; at springing line inside of arches, 19 ft.; giving a batter of 1 ft. on each side. Height of crown above grade, 10 ft. 9 in., thus leaving room for masonry inside the temporary wooden lining.

Tunnels 1 and 2 were lined in a similar manner, except that the batter of side posts were only 6 in.

In these tunnels, through soft material, the heading was supported by temporary timbers. Chambers were then excavated at the sides to below sub-grade, for the sills, and the central core left to support the shores which held the material above in place. As the timbering advanced, the core and false work were removed.

In tunnel No. 12, a short distance in the centre was found to be decomposed granite, and after the tunnel was excavated a light set of timbers was put in. They consisted of arches, each composed of 7 pieces of 10x19 in. timber, with side posts and sills similar to those already described.

In all the tunnels on curves, allowance was made for elevation of outer rail, so that top of cars would remain in centre of opening.

Laborers.—With the exception of a few white men at the west end of tunnel No. 6, the laboring force was entirely composed of Chinamen, with white foremen —the laborers working usually in 3 shifts of 8 hours each, and the foremen in 2 shifts of 12 hours each. A single foreman, with a gang of 30 to 40 men, generally constituted the force at work at each end of a tunnel; of these, 12 to 15 worked on the heading, and the rest on bottom, removing material, etc.

When a gang was small, or the men needed elsewhere, the bottoms were worked with fewer men, or stopped so as to keep the headings going.

The Chinamen were as as steady, hard-working a set of men as could be found. They were paid from $30 to $35, in gold, a month, finding themselves; while the white men were paid about the same, but with their board thrown in. The force at work on the road probably averaged from 6,000 to 10,000, nine-tenths of them being Chinamen.

Tunnel No. 6.—This, the longest tunnel of the road, is parallel to, and about 400 ft. north of Donner Pass. Its length is 1,659 ft., and greatest depth below the surface 124 ft., measuring from grade. The material is granite, of a medium quality, crossed by seams in every direction.

To expedite the work a shaft was sunk about the middle of the tunnel, its dimensions being 8x12x72.9 ft.

Work was commenced on the shaft August 27th, and for the first 30 ft. it was sunk at the rate of a foot a day, after which its progress slackened, from delay in hoisting the material with a common hand derrick.

Meanwhile a house was being built over the shaft, and the hoisting engine was put up. The latter consisted of an old locomotive, the Sacramento, and, by an interesting coincidence, the first engine run in the State. This was geared to a drum 6 ft. in diameter. The house was 50 ft square, containing in addition to the hoisting apparatus, forges, fuel, tamping, etc., so that when snowed in, these articles would be close at hand. The shaft was divided by planking into two compartments, each 5 ft. square; over these were two "jiggers" or transfer tables. The buckets were first of wood, then two additional ones were made of boiler plate, 4 ft. 9 in. square by 2 ft. 6 in. high, outside dimensions, and fitted for side dumping. They were loaded at the face of the work below, run on trucks to the bottom of the shaft, hoisted and transferred to other trucks to run out on the waste bank.

Total days' work on shaft, 85; average progress, 0.85 ft. in 24 hours. Nitro-glycerine had not yet been introduced; with it the progress would probably have averaged 1.5 ft.

Nytro-Glycerine—This was introduced on the work early in 1867, to expedite progress of the summit tunnel. It was made on the spot by Mr. James Howden, and used in the four headings of tunnel No. 6 from Feb. 9th, and to some extent in tunnel No. 8, but not enough to give data for comparison. After the headings of these tunnels were through, it was used in the bottoms.

In the headings of summit tunnel the average daily progress with powder was 1.18 ft. per day with nitro-glycerine, 1.82 ft., or over 54 per cent. additional progress.

In bottom of summit tunnel, average daily progress with powder, full gangs, was 2.51 ft.; with nytro-glycerine, 4.38, or over 74 per cent. in favor of nitro-

glycerine. The same number of men were used with both explosives.

The conclusion we may safely come to from the Central Pacific work, is, that in hard rock tunnels, with the same number of men, over fifty per cent. additional progress can be made by using nitro-glycerine in place of powder, and the expense will be reduced proportionately.

Tunnels of the Union Pacific Railroad.—Tunnel No. 1 is on St. Mary's Creek, about 680 miles west from Omaha, and 12 miles east of second crossing of North Platte River. It was commenced April 30, 1868, and continued from each end until June 8. At that time the two headings were in 86 and 87 ft. respectively, the progress having averaged 2.22 ft. per day. A soft spot was then found in the west end, and there being no means of lining without delay, the open cut was extended to cover the place, and the length of tunnel reduced to 215 ft.

This delayed the work, so that a temporary track had to be built around it.

Tunnel No. 2 is at the head of Echo Cañon, in Utah, about 972 miles from Omaha. Its length is 772.3 ft., being the longest of the Union Pacific. The approaches were started in July, 1868; they are heavy cuts through clay. Rock was struck about the end of August, and found to be like the prevailing formation in the vicinity, an indurated clay, with occasional streaks of soft sandstone. Most of it drilled very easily, but required as much powder in blasting as ordinary rock. While damp it stood firm, but after sufficient exposure to the air to dry out the moisture, it cracked and crumbled like lime in slacking. These qualities made the work very expensive; rock prices had to be paid, and earth slopes taken out.

In starting the headings they had to be supported the same day the excavation was made; but on getting fairly in, the roof would stand well a week or two.

There was an irregular streak of blue sandstone which ran completely through the tunnel near the springing line.

The headings were started at the west end, August 29, and at the east end, September 5; they met January 30, 1869. The tunnel was finished April 3, 1869.

When work was commenced on the tunnel, the track was still 300 miles east, and all the available transportation required to haul tools, materials, and provisions over this gap; it was useless even to think of getting cement in time. There was no suitable stone near the work, and the clay had too much lime to make brick. On these accounts the tunnel had to be lined with timber.

Tunnel No. 3.—This tunnel is through a sharp spur of black limestone and dark blue quartzite, 266 ft. of the former and 242 ft. of the latter, total length 508 ft., on a 3 deg. 30 min. curve to the left. The headings were commenced about September 1, 1868, and met April 4, 1869. Until December 27th the work was part of Brigham Young's contract, and sublet to Sharp & Young. It was then carried on as company work, and let to Daniel McGee, a "Gentile," February 9th. Not being finished in time for the rails, a temporary track was built around it, partly on a 22 deg. curve, 260 ft. radius, around which trains of 23 cars were taken.

Nitro-glycerine was fairly introduced into the tunnel by February 23d. About 20 per cent. of the tunnel men struck on account of its use, and were not replaced, as two shifts on the bottoms were found enough to keep them up with the headings, notwithstanding the additional progress they too were making; three shifts had been required with powder. About twice as much work was done per man with nitro-glycerine as with powder. The use of nitro-glycerine in tunnel No. 3 saved the company nearly $40,000.

Tunnel No. 4.—Length 297 ft.; alignement 4 deg. to left; material, quartzite, similar to that in tunnel No. 3. Headings were commenced about September 10, 1868, and tunnel finished January 29th; nitro-glycerine was used to take up the last 180 ft. of bottom, which it did in 11 days; making the remarkable progress of 8.18 ft. per day from each end. In tunnel No. 4, 1,960 cubic yards were taken out with powder, requiring 289 kegs and 7,000 ft. of fuse, or $3\frac{7}{10}$ lbs. powder and $3\frac{6}{10}$ ft. fuze per cubic yard.

Comparison between the two roads.—The total length of tunnelling on the Central Pacific is 6,213 ft.; on the Union, 1,792. The cross sections of tunnels on the two roads are practically identical.

The circumstances and materials varied too much to make an accurate comparison of progress in tunnels of the two roads. The greatest average daily prog-

ress of heading on the Central Pacific, through granite with nitro-glycerine, was 3.29 ft. On the Union Pacific, through quartzite, about as hard as granite, 4.62 ft. Each road has done over 8 ft. per day at a single face in taking up bottom.

The laborers on the Central Pacific were mostly Chinamen, paid $30 to $35 gold per month, working three shifts per day in tunnels, and 12 to 15 men in a heading. On the Union Pacific the laborers were white men, paid $3 to $4 per day currency, generally working two shifts per day, and 8 to 12 men in a heading, on tunnels 1 and 2, and three shifts of 14 to 16 on tunnels 3 and 4.

The Central Pacific Railroad was built under the direction of S. S. Montague, Chief Engineer. The location and construction across the Sierra Nevada were in charge of L. M. Clements, Resident Engineer. The account of tunnels on that work is principally compiled from a report on the subject written for the latter by the author, while engaged on tunnels 6 to 13 of that work.

The Union Pacific Railroad was built, and its location revised, under the direction of S. B. Reed, Engineer and Superintendent of Construction. The accounts of tunnels 1 and 2 are from personal observation, and of tunnels 3 and 4 from data furnished by Edward P. North, Resident Engineer of work in Weber Cañon.

WROUGHT IRON AND STEEL.

THE FLUO-TITANIC PROCESS.

This process is a new discovery, and has for its object the production of wrought-iron and steel from crude cast-iron, by the use of fluxes, and without manual labor. The results obtained from experimental operations have been so certain and uniform as to leave no doubt of its success when applied on the largest scale of manufacture.

Wrought-iron is usually made from pig-iron, and it is the purest of the different sorts of iron produced metallurgically. It is often contaminated with substances chemically combined, such as sulphur, phosphorus, and silicon, or its carbon is unevenly distributed; all these circumstances modify the properties of the wrought-iron—strength, property of welding, hardness, etc.

The manipulations in the production of wrought-iron have been principally directed to removing as much as possible of the impurities contained in pig-iron, mainly by oxidation of most of the carbon; and in order to render the wrought-iron tractable, both at low and high temperatures, the foreign admixtures (sulphur, phosphorus, silicon, etc.) must at the same time be separated by oxidation, forming the volatile substances, whilst the fixed substances may be scorified.

The oxidizing agents are, chiefly, the oxygen of the atmosphere, and fluxes rich in oxygen, usually applied at the melting temperature (in fineries, reverberatory furnaces, or in the Bessemer converter). The puddling process, conducted in reverberatory furnaces, is in general use for the production of wrought-iron, and is about the only available method, until now, for making wrought-iron from pig-iron, in which sulphur and phosphorus are present. In Bessemer's process very grey pig-iron, almost wholly free from sulphur and phosphorus, is required. Bessemer conducts liquid iron from blast furnaces into special apparatus, in which he burns out the carbon by blast, and without the application of fuel. The temperature thus produced, together with that of the burning and liquid iron, is sufficiently high to liquify even malleable iron. In this process it is very difficult to separate the carbon to the required limit, when employing a very pure iron, on which account a friable burnt iron, poor in carbon, is likely to result; and this iron will be red and cold-short at the same time, when treating impure cast-iron, as phosphorus and sulphur cannot be sufficiently extracted, owing to the rapidity of the operation. This circumstance, and the great loss of iron, are the reasons why this method has not been generally introduced; but it is applied in the manufacture of steel, when it is more easy to fix the point of decarbonization.

Consequently, there has been the want of a process that is economical as to cost of production, and certain as to results,

that will produce superior qualities of wrought-iron and steel from pig-irons that are too poor for the Bessemer process (and which comprise over 90 per cent. of the pig-iron produced), and from which better results are to be obtained than by puddling; and that, at the same time, will do away with the waste attending the other processes, and without the manual labor of puddling.

All of these conditions are fulfilled in the new fluo-titanic process; which consists, as its name implies, in the combined use of fluor-spar and titaniferous iron ores with liquid cast-iron, for removing carbon, silicon, sulphur, and phosphorus. This process differs from other processes in the respect that it is reducing as well as oxidizing, and is not attended with the waste of the other methods; on the contrary, the iron in the titaniferous ore is rendered metallic by the reactions of the oxygen in the ore with the carbon in the pig-iron.

Several modes of application have been tried with success. In one, granulated cast-iron was charged into a furnace in admixture with titaniferous iron ore and fluor-spar, both pulverized. When the iron melted, the heat dissolved the fluor-spar, which combined with the titanic acid in the iron ore; and, by reason of the affinities of these two substances for carbon, silicon, sulphur, and phosphorus, these substances were taken from the iron in the form of vapor and slag, leaving the resulting wrought-iron in the liquid state, to be run off into ingots to be hammered or rolled.

Another method of treatment is, to mix titanic iron ore with fluor-spar, applied at the bottom of a vessel or furnace and rendered plastic by means of heat or by mucilagenous substances; and to run the molten cast-iron in upon them. When titaniferous cast-iron is used, fluor-spar will only be required to produce the same result. The reactions between the fluor-spar and titanium with the carbon, silicon, sulphur, and phosphorus, are wholly spontaneous, and last from 20 to 30 minutes after the fluor-spar melts.

In order to produce steel of any required grade by this process, it is only necessary to vary the proportions of fluor-spar and titaniferous iron ore and the grade of the pig-iron. Owing to the quick reactions when using white iron, this iron is preferred when wrought-iron is required, and graphitic cast-iron when steel is wanted; in which case the proportions of fluor-spar and titanferous iron ore may be so graduated as to remove all of the silicon and other impurities, and leave just the required amount of carbon in the metal to form the grade of steel required, the carbon becoming chemically combined.

The fluo-titanic process is more economical with the same grades of pig-iron as compared with the Bessemer process, for producing steel, as there is no loss of weight; on the contrary, there is a slight gain over the weight of the pig-iron used, by the reduction of the iron in titaniferous ore to the metallic state, before referred to, which becomes incorporated with the product of conversion; whilst, by the Bessemer process, only about 78 per cent. (sometimes 80 per cent.) are produced from the pig-iron, 70 per cent. of which are pure ingots, and 8 per cent. are waste steel.

As compared with the puddling process, the fluo-titanic is as marked in economy and superiority of product as it is with the Bessemer process (as will be seen by the analyses of results obtained). Manual labor is unnecessary in the new process; and about one-half the fuel is required for the conversion, as compared with puddling. When the puddling process is conducted in the "dry" way, there is a loss of iron amounting from 8 to 10 per cent.; and when the "wet" or boiling system is used, about 45 per cent. of rich oxide of iron is required; and there is but little or no less from the weight of the pig-iron charged. The items of waste by the "dry" method, and the use of oxides by the "wet" methods of puddling, about counterbalance each other as to cost of production; and are about equal to the cost of fluor-spar and titanic iron ore used in the new process, so that the net gain derivable from the use of the new process, over puddling, will be in the saving of the manual labor of puddling, and one-half of the fuel, and in the superior quality of the result, and in the increased production from the same investment of capital.

The proportion used of titaniferous iron ore is about 5 cwt. when containing 35 per cent. of titanic acid, 60 per cent. of oxide of iron, and small portions of

silica, manganese and magnesia, and 2 cwt. of fluor-spar to a ton of pig-iron.

In the experiments that have been made, the most inferior iron produced in large quantities was selected. It is well known in the trade, as the English Cleveland pig-iron. The specimen selected was white iron, produced by the irregular working of the blast furnace ; and it contained more impurities than if produced by the regular process. In the items of sulphur it was in excess of the published analyses of the grey pig-irons of that district. The analyses of the iron used, and of the resulting refined metal, are as follows :

PIG-IRON.

Combined Carbon	3.3710
Silicon	1.8139
Sulphur	0.3620
Phosphorus	1.3810
Iron by difference	93.0721
	100.0000

REFINED METAL.

Carbon	Traces
Silicon	None
Sulphur	0.0620
Phosphorus	0.1399
Titanium	0.0215
Iron by difference	99.7766
	100.0000

The above metal, when produced on a large scale, will be in the form of blooms or ingots ; and it is a fact well known to metallurgists that the subsequent working into bars or other required forms generally reduces the amounts of phosphorus and sulphur, each from 0.03 to 0.05 ; so that the refined bars produced by the new process will not contain more of these substances than the highest grades of wrought-iron produced, such as Low Moor and other brands that command the highest rates, and are in great request for engineering purposes, bringing higher prices than many kinds of steel. The amount of phosphorus in the foregoing analysis is less than Prof. Gruner, of the Ecole des Mines, reports in the Heaton cast-steel, which is produced at much greater cost.

From the foregoing it will be obvious to all practical iron workers that there are many grades of cast-iron that are too impure to be worked by the old method into best cast-steel, which will be made, by the new invention, available for this purpose.

In the "Engineer" of October 22d, of last year, is published a tabular statement prepared by Mr. D. Kirkaldy, showing the great ductility of iron produced from titaniferous ores, which had been rolled into boiler plates, bars, and other engineering work. The remarkable statement is there made that some of the bars were drawn as much as one-quarter of their length before breaking.

Titaniferous iron ore is generally considered in the United States as being of no use for the manufacture of pig-iron, and has not yet entered into the production of iron or steel, except experimentally. It is found in large quantities in the State of New York, of excellent quality ; and it bids fair to become one of the most useful ores of iron.

Fluor-spar is very abundant in Ohio, Indiana, and Illinois.

This process is the invention of James Henderson of 30 Broadway, New York, and has been patented in the United States and Europe.

ORDNANCE EXPERIMENTS. — At Fortress Monroe a new projectile has been lately tried, which the inventor, a citizen of Iowa, is anxious to get adopted by the Ordnance Department. The shot is conical, with a rifled bore inside. An 8-in. shot, with the inner bore unloaded, weighs about 200 lbs. A shot of this kind has a bore $3\frac{1}{2}$ in. in diameter and 8 in. deep, which is loaded by $\frac{1}{2}$ lb. of powder, a $12\frac{1}{2}$-lbs. shot, and a brass plug in two pieces, which fits into the muzzle. Thus charged, the projectile is fired from an ordinary rifled cannon. The theory is, that after the projectile has almost spent itself, a time fuse will explode the charge inside, and the $12\frac{1}{2}$-lbs. shot will be discharged as if from a cannon, the entire range thus accomplished being from 8 to 10 miles. At first the experiments were not successful, the plug and ball coming out before the projectile had travelled a mile. Afterwards the plug was screwed in, thus keeping the ball in position until the fuse burnt down to the powder. One paper suggests that the principle, if carried out, will make us invincible in a foreign war, as the gunners at Fortress Monroe will only have to get the true range to batter down the walls of Pekin. The "New York Herald" describes the projectile as a "gunpowder boomerang," and hopes the "first shot may always be so contrived as not to turn any somersaults, and so send the second shot the wrong way."

COUNTERBRACING.

By S. H. SHREVE, C. E.

Probably in the practice of foreign and American engineers, there is no point about which they differ more widely than that of counterbracing in bridges. Even among American engineers there is much variance and dispute as to the true purpose of counterbraces. To Mr. Haupt belongs the honor of first teaching that they were solely for stiffening the truss, and consequently should be of the same section from one end of the bridge to the other. This doctrine has many followers, even at the present day, but the more intelligent of our engineers have seen its fallacy, and in our best bridges, as now constructed, the counterbraces are proportioned to carry a part of an uneven load. Still, the effects of the early teaching on the subject are everywhere apparent in their proportions, and it is pertinaciously clung to as an American doctrine, that they must extend to the very end of a bridge.

It is the custom now, to calculate the strains upon a bridge under the maximum uniform load, and from them to proportion the main-braces and chords. Then the load is brought on, panel by panel, and the counterbraces are proportioned to carry a certain part of the weight to the farther abutment. This certainly gives all the strains that can come upon any member of the bridge; but it does more—it gives too much. The weight of the bridge itself should enter into every calculation, as well for the partial as for the maximum loads.

It is probably too self-evident to need proof, that in the same panel a main and a counterbrace cannot act at the same time. One only can act, and if the horizontal thrusts of the weights on either side the panel balance, neither of the braces act. If a truss be divided into an uneven number of panels and is uniformly loaded, the braces in the centre panel have no action.

Col. Merrill, in his recent work on Bridges, refers frequently to "the counterbalancing of equal weights similarly situated on symmetrical trusses," "each balanced weight goes undivided to the nearest abutment." But why do equal weights similarly situated counterbalance? Is it not because they produce equal horizontal action? Suppose they are not equal weights, is it not possible for them to produce equal horizontal action and counterbalance by not being similarly situated? Or, suppose the weight on one half to be concentrated at its centre of gravity, it will still counterbalance the weight on the other half, because it still produces the same horizontal action.

Let one-half of a bridge be uniformly loaded with a certain weight, and the other half be uniformly loaded with a greater weight, and let this be a permanent load; when the braces are arranged to bear this, none of them will cross each other, but from the point where the horizontal strain is greatest they will incline to either abutment, as in a uniform load they incline from the centre. If a bridge be uniformly loaded, as stated before, no counterbraces are necessary, and there is no shearing strain or vertical force at the centre. Add to this, at one end, a load, and the result is that the place of the greatest horizontal strain leaves the centre and approaches the load, its approach being guided entirely by the amount of the load. From this point of the greatest horizontal strain the braces must now incline both ways to the abutment. In other words, counterbraces are needed between the point mentioned and the centre only.

If this uniform load be taken as the weight of the bridge, we can easily see how it is affected by the advance of a train. Remembering that two braces cannot work counter to each other in the same panel, it is evident, if we have a weight at one end of a panel acting upon the main-brace, that it requires a greater weight at the other end to act upon the counterbrace; for an equal weight only neutralizes the vertical force of the first weight and produces only a horizontal action; therefore the second must exceed the first before it can affect the counterbrace.

Let us now apply this to one of the examples in Col. Merrill's work, say the Jones Truss, and use, for greater simplicity, only the vertical components of the strains. Unloaded, the weight of the

bridge produces a strain on the main-brace in the second panel, of 60,937.5 lbs. Bringing the head of the engine to the centre of the panel (advancing on the bridge) it is calculated that it imposes a strain of 1,100 lbs. on the counterbrace in this same panel; but this cannot be, for the two braces cannot act at the same time. In truth, it lessens the weight on the main-brace in this panel by 1,100 lbs., making it 59,837.5 lbs., increases the weight on the first main-brace, affects the other braces, and draws towards it the point of greatest horizontal strain. So far, counterbraces are therefore useless. The same case occurs in the third, fourth, fifth, and sixth panels, but in the seventh the weight from the engine and train that is carried towards the centre, is 21,636 lbs., while that from the bridge itself on the main-brace, is 14,062.5 lbs., and a counterbrace now becomes necessary, but it has only a weight of 7,573.5 to sustain. This can easily be proven graphically.

We need therefore in this truss only two counterbraces on either side the centre, and they bear 18,000 lbs. less than they are proportioned for, and there are about 7,500 lbs. of counterbrace entirely useless in one truss on the Jones plan, as given by Col. Merrill. The same misapprehension prevails in regard to the other plans, and has probably arisen from never taking into consideration the effect of the weight of the bridge itself when calculating the effects of a partial load.

TRACTION OF LOCOMOTIVES.*

From "The Railway Times."

Traction of locomotives is the work performed through the machinery, and developed at the rail. To many it is synonymous with power; which, strictly speaking, is wrong. Traction analyzed is but weight. Power is weight multiplied by time. There is not, and cannot be, practically, such a calculation as horse-power of a locomotive, from the fact that an engine may be running fast, and using little steam, by partially closing the throttle, and still show more power than when running slow and using heavy pressure to end of stroke. The reason is apparent. But the force it exerts, and the velocity it moves at, can be calculated.

To those who have seen a dynamometer at work, traction and its relations are a study. I do not propose to enter into a series of precedents on this subject, but merely give my impressions as they came under my observation. And when I say impressions, I do not mean facts or conclusions, but only that transition state between them and emotions —that broad, middle ground, where conjecture is developed by experiments as truth, or abandoned, from the same clause, as misdirected impulse.

On first view, one hesitates, from the extent of ground embraced, including the resistances of over-loaded cars, cars out of order, bad lubricants, friction, gravity, condition of engine, rails, track, curves; proportion of dead to paying load might possibly come under this head. The ground is so wide, opportunities so scarce, time so limited, and ability probably lacking, that a mere cursory view is all that one, leading the active life that we do, can give this subject.

On the roads of the South, where ballasting is limited, where the heavy rains of winter preclude, or nearly so, all work on it, and at the same time when the heaviest traffic is carried, is probably where resistances to traction are most varying.

An engine weighing 30 tons, giving a weight on each driver of 10,000 lbs., at a speed of 30 miles per hour or 44 ft. per second, strikes a low joint; the force or momentum to be absorbed by springs, etc., is enormous, as per example: Height due that velocity by formula is $44.8\ 2 = 5.5\ 2 = 30.24$ ft. $10{,}000\ 35.25 \times 64 = 440{,}000$ lbs.; or force enough to move 2,750 cars of 16 tons each, were it possible to so apply it; which it is not. Some of this, a great deal too, is absorbed by the acuteness of the angle that a line drawn from point of contact to centre of wheel would make, which in a 6 feet wheel is 78 degs., and in a two feet wheel is 65 degs. The balance is taken up by

* The above paper was presented by Mr. L. H. Sellers, of the Memphis and Charleston Road, before the American Railway Master Mechanics' Association.

the spring and reciprocations of equalizing beam. But for this no machinery could stand it. If the blow was received directly opposite the centre of the wheel horizontally, it would bend or break the frame or crowd the pedestals off.

The engine passes over the place with an interval between the striking of it by each driving wheel of $\frac{1}{8}$ of a second, a scarcely appreciable time, but long enough for dynamometer to show, by a jump of 1,000 lbs. or 1,500 lbs., that it also felt the blow, and long enough also for the engineer to feel each wheel as it strikes. This is but one of the incidentals of high speed on rough track. Another is the fact,that the trucks are alternately going up and down hill. The sinking of one tie but a single inch under a heavy loaded wheel makes a rise of 1 in 30 for that wheel the traction force necessary to overcome, which is 66 lbs. per ton. But it is said, there is the down grade equal to the rise; this is scarcely so, as the low place gives way under the wheel, and only reaches its lowest point where the weight of the wheel forces it there, leaving nothing but the spring of the rail to assist up the hill thus formed. And an inch is scarcely half of what ties sink during the long wet spells of the South. This adds to power required, and consequently to cost of said power. That axles do not break oftener under such treatment seems strange.

An engine 15×22, 5 ft. wheel, 120 lbs. pressure, should exert a tractive force of 9,000 lbs. at least. On a grade of 48 ft. per mile, with a load of 5 freight, 1 baggage, and 2 passenger cars, weighing with engine 350,000 lbs., it gave out on dynamometer 8,000 lbs. to start; after a revolution or two 9,000 lbs. until train was under headway; on pulling lever back 2 or 3 notches it required a constant strain of 6,000 lbs. to attain and maintain a speed of 25 miles per hour. On grades of equal heights and similar curves, with a start which is merely using the work stored up on the down hill, and can be calculated by multiplying weight by velocity, being what is called momentum or headway, the amount due gravity was 3,181 lbs., friction 2,134 lbs., leaving 2,685 lbs. to be absorbed or used up by suddenness of start; or rather it requires that to overcome the dead weight or inertia, and establish motion in a short distance. Engineers have all observed how long it takes to get up speed on a train when using a moderate throttle and cutting off pretty well back.

A calculation as to the assistance of momentum, compared with actual results, as above. It required 6,000 lbs. to maintain the same speed from a state of rest that 3,000 did with a start. 25 miles per hour is 37 ft. per second. Call the grades 2,600 ft. long, the statement is 350,000 lbs. weight of train by 24 lbs. height of grade=..... 8,400,000 lbs.

Friction at 18 lbs. per ton for engine and 10 lbs. for cars $2,134 \times 2,600$.. 5,548,400 "

Making a total of..... 13,948,400 lbs.

3,000 lbs. amount dynamometer showed by 2,600 =..... 7,800,000 "

Leaving, to be overcome by headway, a deficit of 6,148,400 lbs. which, divided by total weight of train 350,000 lbs. is 17 ft. as the height due velocity, or the height that the weight would have to fall to make up deficit. Reduced by formula, square root of $17 \times 8 = 328$ ft. per second, giving an inherent velocity in train at foot of grade, of 22 miles per hour.

With a $14 \times 24 \times 60$ in. wheel, 100 lbs. to 120 lbs. pressure giving a tractive force of 8,000 to 9,000 lbs. and a load of 250 tons, it required 6,000 lbs. to start on a level, 6,500 to 7,000 lbs. on a grade of 45 ft. per mile, or 1 in 117. The engine stalled, as it passed over centre; just before stalling, the hand fell as steam was released in cylinder to 4,000 lbs. At low speeds, from 5 miles upwards, this did not occur. On broken grades of equal height this train was readily kept at a speed of 18 to 20 miles per hour, with only 3,000 lbs. shown, or about half what it required to start the same on a level.

Having repeatedly tried light passenger trains, say 3 to 5 cars, I have found that while it required 3,000 lbs. to start them, the speed was easily kept to the maximum, 25 miles per hour, with from 1,500 lbs. to 2,000 lbs. on grades, and as low as 1,000 lbs, on level.

These results vary with different engines, as some roll away from train on down grades, while others set back against

it and require to be pushed. Observing as closely as I could, I have been able to get all the calculated power from engines that were in any kind of condition, after a little speed had had been attained, say 4 miles per hour. Few give it on a dead start; in fact, I have not seen any do so. This is to be attributed to the lead, or rather early exhaust, as I have not been in the practice of giving any lead or steam side at full stroke, judging that the increase on link was enough, even to overcome the loss of it by lost motion in valve gearing.

ON THE MANUFACTURE OF CRUCIBLE STEEL.

By R. H. SMITH, F.C.S., Etc.

From "The Artizan."

A great deal is being said about the production of cast-steel directly from iron ores, or its manufacture from inferior kinds of English iron; but little is known or said (outside the immediate manufacturing districts) as to how the immense quantities of this substance are produced at the present time. The conversion of iron into steel is, perhaps, to be classed among one of the most peculiar, but, at the same time, interesting processes with which chemists are acquainted.

The ordinary converting furnaces are of a conical shape, the bar-iron laying in stone pots, in contact with charcoal; and the heat to which the iron is exposed is regulated according to the purpose for which it may afterwards be required. The time generally occupied in what is termed "conversion" is about three weeks, a week being taken to raise the heat to a sufficient degree, a second to maintain it at the required temperature, and a third to gradually cool the furnace. When cold, the bars are withdrawn, and found to be covered with blisters, and, if broken, possessing a fracture totally different in appearance to that shown by the iron before treated in the manner described. Several tempers, as they are technically called, are produced in one furnace, and much care is necessary in selecting them out for the different requirements of the melter.

Too much care cannot be taken in the melting of steel, as the after-work so much depends upon this part of the process. The melting-holes are on a level with the floor of the furnace-room. Each hole has a flue; and some six, twelve, or more, of these form a flat stack. The grate bars at the bottom of each hole are approached by means of a cellar below. The crucibles, or pots, as they are called, made from a mixture of several kinds of clay and a little coke-dust, are formed into shape by means of a plug and flask. The pots are annealled over night, and when at a dull red heat in the morning placed in the holes by means of tongs, each furnace taking two pots.

The bar-steel of the required hardness is now broken up, and the crucible charged by means of an iron funnel. The first heat, as it is called, will take from four to five hours before it is ready to be poured; but this greatly depends on the nature and hardness of the steel. The holes are watched and worked by the puller-out; but the word to draw the pot is given by the melter.

The puller-out now lifts the crucible from the hole with large tongs, and places it upon the floor of the furnace. Its contents are then poured by the melter into a mould, made of cast-iron in two pieces, covered with a coat of coal-tar soot, and are held together by rings and wedges.

Great care is required in pouring or teeming the steel, as it is technically called, and skill in judging the proper heat when to cast it. Mild or soft steel should be teemed immediately the pot is withdrawn from the furnace; but hard steel may often remain a few minutes with advantage. Each crucible should last one day, and is used three times, with charges of fifty, forty-five, and forty pounds respectively.

All steel above a chisel temper contains 0.90 to 1.00 per cent. of carbon. If well melted it will settle down in the mould, leaving a small hole at the top of the ingot. If, however, the molten steel has not remained long enough in the fire, it will pour fiery; and if the ingot, on cooling, be broken, it will be found to be full

of small holes, called honey-combs. Great precaution must also be used in not allowing the metal to remain too long in the fire, as hard steel, when of good quality, will soon scorch, and so render the ingot very brittle.

Well melted steel (say of a cool temper) may be thus known The ingot will be of a blue color, with a smooth and even skin; the fracture of uniform brightness, and the outer edge perhaps slightly scorched.

Another very important operation to which steel is subject is the hammering; and probably more good steel is spoiled in this depaı tment than any other. The ingot should be well soaked in the flame of the forge furnace, and not at once (as is often the case) put into a dead fire—where the heat is what is called dead—and where no flames surround the ingot.

The fineness of the fracture of a bar of finished steel greatly depends upon the heat that the bar is allowed to retain when the finishing stroke of the hammer is upon it. Coarseness and fineness of grain, as judging the temper of quality of cast-steel, is far overestimated. It is, to a certain extent, an indication of hardness; but so much depends upon the way the bar has been finished, that it is of little practical value. However, best cast-steel, especially when hard, will show a fracture of a silky nature; and when soft, will look bright, and shine like glass.

Common cast-steel, on the other hand, will lack that brightness which is so characteristic of good steel; it will look dull, and have, so to speak, a leaden appearance about it.

In the working of steel too much care cannot be bestowed; and where, as in razor making, the workman is required to use a steel containing 1.50 per cent. of carbon, the durability of the razor will almost entirely depend upon the heat to which he subjects it while forging it into shape.

A useful tool-steel will contain about 1.2 to 1.35 per cent. of carbon. Spindle-steel, or large size turning tools, will work well if containing about 1.15 per cent. of carbon. Chisel-steel is a temper much used, will harden at a low heat, and possesses great toughness. Steel of 0.85 to 0.75 per cent. of carbon will weld easily, and is adapted for cold-sets, or tools where the principal punishment is on the unhardened part.

In melting, charcoal is largely used when the bar-steel is not of the required hardness. Wolfram and titanium are occasionally used, but with little advantage.

Binoxide of manganese is universally employed. It forms a good flux, and protects the molten steel from the action of the air.

Spiegeleisen is much used in Sheffield. It is an alloy of iron with manganese and carbon. The following is an analysis of a good spiegeleisen :

Iron (by difference)	84.78
Manganese	10.21
Carbon	5.01
	100.00

Among the many irons employed in steel-making, none have acquired the reputation that those imported from Sweden have won for themselves, and especially those known as the Dannemora marks.

Such brands as double Bullet (OO) and hoop L (L) command a high price, and are much used where the best quality of steel is required. Second Swedes, such as Wand Crown, Steinbuck, Great S, K6, etc., are good-bodied irons, largely employed, and making a very good steel. Of the commoner marks may be quoted (CW) SV8) Spider, and $\overline{\text{I-G}}$; and where a high price cannot be obtained for the steel, such brands are recommended, being found to melt and work well. English irons and spring ends are melted, but make an inferior quality of cast-steel.

The following is an analysis of tool-steel :

Iron (by difference)	88.34
Carbon	1.31
Manganese	0.12
Silicon	0.19
Sulphur	0.03
Phosphorus	0.01
	100.00

THE earliest stained glass of which we read—the earliest in England, at least—was in the possession of Rivaulx, about 1140.

THE DARIEN CANAL.

From "The Scientific Journal."

The success of the Suez Canal will no doubt give impetus and encouragement to enterprises of the same kind.

Since the year 1860 a French civil engineer of talent has been engaged in the difficult and dangerous task of surveying the Isthmus of Panama, for the purpose of finding the best line for a ship canal across it.

We clip the following extracts of his final report in our files of the New York "Tribune:"

The proposed canal has its entrance on the Atlantic side at Puerto Escondido, where vessels can anchor in a depth of from 17 to 44 fathoms. Thence the proposed canal follows the valley of Turgandi, and passing behind a small hill called Tarers, continues on in the valley of the River Tanela, to the source of this river. The hollow in the chain of hills, at its highest point, is here only 46 meters above the level of the sea. The canal would here enter the valley of the Pucro (on the Pacific slope), and follow it until reaching the Tuyra, 4 miles above the point named Santa Maria Real, at which place it enters the river, and thus is brought 3 miles below the highest point reached by the tide in the river Tuyra. The canal will require 88 kilometres, or 22 leagues, of excavation. From the western entrance, at Santa Maria la Real, to the Gulf of San Miguel, by "Boca Chica," there will then remain 65 kilometres to be navigated, in a river which at present has a profundity of from 7 to 20 fathoms. The distance from ocean to ocean will thus be 153 kilometres, or 38¼ leagues. The height throughout the proposed line, taking the highest and lowest points, presents an average of 11 metres 90 centimetres. The canal would be 70 metres wide at top, and at the bottom would be 50 metres—thus allowing ample room for the passage of the largest steamer yet built. Considering the diverse formations presented by the different sections of the route, which comprise earth, clay, schist and earth, sand, lava, stones and rocks, the following figures present the maximum cost of the work, and which would be reduced materially by the employment of machinery to the excavations :—

87,800 metres at $600,000 the kilometre	$52,680,000
Allowance of 10 per cent. for any difficulties which may arise in the excavations	5,320,000
Machines, tools, &c	800,000
Clearing the line	1,000,000
Expenses of general management for 5 years	1,000,000
Agencies in Colombia	100,000
Engineers and superintendence of the work	600,000
Houses, sheds, hospitals	800,000
Sanitary service and medicine	100,000
Extra provisions	400,000
Lamps, levees and wharfs	200,000
Drags	200,000
Ports at each extremity of the canal	200,000
Telegraphs, double wire and exchanges	200,000
Railroads, &c	2,000,000
Provisions for directors, engineers, agents, instruments, &c	400,000
Mules	200,000
Ammunition, arms, mining powder	200,000
Steam and sailing vessels to bring provisions	400,000
Accidental expenses	3,000,000
Total	$70,000,000

The quantity of earth to be excavated in order to open the Colombian Canal is 125,000,000 cubic metres, which being divided into 20 working sections give 6,000,000 cubic metres to each section, so that if the work were to be commenced along the whole line, within a period of from 3 to 6 years the canal would be open for navigation.

The earth to be excavated may be divided into the following proportions: 1. Earth, sand, clay, etc., 45 per cent. 2. Small stones and stones removable by labor, 34 per cent. 3. Rocks of different formations which will require blasting, 21 per cent.

The highest point of the saddle in the chain of hills is 46 metres in height by 9,000 metres in length, and will require the removal of 31,000,000 cubic metres of earth, being equivalent to the fourth part of the whole work.

The whole of this data is obtained from documents now in possession of the Society, which are already approved of in Europe, and will be presented to the Congress about to assemble in Bogota. The maps of the Society have been approved by the Admiralty of England (and also by that of France) as the most complete.

GUN EXPERIMENTS.

From "The Artizan."

It is deeply to be lamented that a certain amount of antagonistic feeling appears to exist between those who regard the present Ordnance service-gun with favor, and those who put their faith in our esteemed member, Sir Joseph Whitworth, and the merits of his rifled ordnance. The Ordnance authorities, on the one hand, appear to hesitate adopting, or at least, trying what I am to understand the Admiralty authorities, on the other hand, have determined to give a fair trial to, namely, the 35-ton gun on the Whitworth rifled system with elongated shot. If this intention be realized, there will be an excellent opportunity of a fair trial on what I conceive to be correct principles, stated thus :

The value of a rifle-gun may be properly estimated by the lowness of its trajectory and the length of its shell. To obtain these two important elements in the greatest degree, it is requisite that the gun should consume a column of powder not less than three diameters in length, and without producing a permanent alteration in the diameter of its bore by the explosion. The power of hitting objects at unknown distances depends greatly on the lowness of the trajectory. At very short distances a shorter shell may give a somewhat lower trajectory than at longer ones.

But for destructive effect at very short distances, Sir Joseph Whitworth clearly showed in the paper he read on the penetration of armor plates, at the meeting of the British Association at Exeter, that shells twice the ordinary length gave the greatest penetration, while they contained double the ordinary bursting charge.

It is highly desirable that there should be some fixed standard of length of range at which all guns should be fired. If such standard of length were adopted, the merits of guns and ammunition would be at once known, by simply recording the elevation at which the standard distance was reached and the length of the shell, expressed in diameters of the bore. The longer the projectile, and the lower the elevation at which it is propelled, the greater is shown to be the power of the gun.

One thousand yards may be now considered a short range for artillery; and as upwards of 11,000 yards (more than six miles) has been attained, a standard range of from 2 to 3 miles would answer the purpose. If this were carried out, any one would be able to form a correct opinion of the value of any particular gun. For want of some standard, very confused notions now prevail on the subject of rifled guns.

It is very difficult to attempt to compare two guns having nothing in common. For instance, to compare the 7-inch service breech-loading gun and the 7-inch Whitworth :

	Elevation.	Shell. Diameters long.
7-inch service gun, range 3,660 yards	9° 54′	2
7-inch Whitworth, range 5,000 yards	10°	3½

Although it is obvious how much more powerful one gun is than another, it would have been far better for the ranges to have been the same, and the difference shown only in the elevations, and the length of the projectiles given in diameters of the bore. The length of the Whitworth shooting gallery at Manchester being 500 yards, it was the practice to compare the performances of different rifles and their ammunition at that distance, and 500 yards became the standard of length.

The following shows the qualities of the Enfield and Whitworth, as developed in April, 1857 :

	Elevation.	Length of Bullet. Diameters.
500 yards range, Enfield rifle, large bore	1°	2
500 yards range, Whitworth rifle, small bore	1°	3

Other qualities, such as accuracy or figure of merit, charge of powder, weight of bullet, weight of rifle, etc., it may be desirable to know; but the key-notes are elevation and length of shell, which at once decide the value of the arm. In 1852, the average shooting of six rifles made by the best makers in London, was 33 in. deviation. The shooting of each rifle is recorded in a book printed by the War Department, which I have seen, and which affords evidence of the great advance made in the science of gunnery since that time.

The shooting of the Whitworth rifle is now, as it was at Hythe in April, 1857, 4½ in. at 500 yards, with 10 successive shots.

An infantry soldier will probably be as well armed with the new small-bore breech loader, as far as accuracy, rapidity, and distant firing are concerned, as he is ever likely to be. He is now able to fire 8 projectiles, 1 oz. each, per minute, and make good practice at one thousand yards. But the power of infantry for attack or defence, even with the new breech-loader, falls far short of what small bodies of infantry could do, if armed with 3-pounder field-guns drawn by 2 horses; each man would be able to fire a far greater average weight of ammunition, and of much more destructive character, than with the rifle. The trajectory at 1,000 yards for the 3-pounder gun, is not one-half that required for the rifle.

IRON AND STEEL NOTES.

The Iron and Steel Trade.—The Bulletin of the American Iron and Steel Association puts the product of pig iron in the United States, in the last five years, as follows: In 1865, 931,000 tons, net; 1868, 1,603,000 tons; 1869, 1,900,000 tons. During the last eighteen months, sixty-five new blast furnaces have been erected. Nineteen of these were in Pennsylvania. Thirty years ago the entire product of pig iron in the United States was but 50,000 tons, and the largest furnace was only capable of producing 1,500 tons annually. In regard to steel, the "Protectionist" has the following: "Within the last six years it has been demonstrated that the steel-producing qualities do exist in American iron, and many of our best edge tool manufacturers and machinists testify that steel, both cast and rolled, made in Pittsburg from American iron, is fully equal to the best English makes. The steel-producing capacity of the works in and around Pittsburg alone is estimated at 75 tons per day. This industry may, therefore, be deemed an accomplished fact, and, brief as its history is, it has already exercised an important influence in controlling foreign prices." It is shown that American axes, shovels, spades, hoes, etc., have entirely taken the place of foreign tools. Nothing equal to them in shape or finish is made abroad, and they are now largely exported. American butts and hinges of all kinds are cheaper and better, and entirely exclude all foreign goods. In cutlery of all kinds, the medium American qualities, of which the largest bulk enter into consumption, are cheaper and better than those of foreign importation; only the very low and worthless grades, or the very expensive and luxurious styles, can now be imported.—*Pittsburg Evening Chronicle.*

Puddling Steel Rails.—At a recent meeting of the Iron and Steel Institute (England), held at Middlesbro', some valuable and practical information was given on the subject of the manufacture of steel, and its adaptation to rails.

Mr. Edward Williams, the General Superintendent of Bolckow & Vaughn's Works, stated: "Strenuous efforts had been made by nearly all the great ironmakers to produce steel-topped rails, which, it was hoped, would be made much more lasting than the usual piled iron rails, and less costly than ingot rails. Puddled steel seemed to offer a cheap and good material for this, and after some difficulty to begin with, it was produced of very uniform quality. It was, no doubt, a material capable of resisting well the wear and tear of railway stock, but it could scarcely be welded at all, and as it could not be obtained in solid blooms for rail sizes, the system failed, and had been abandoned in this country (England) at least, entirely."

Thus we have the opinion of one of the most practical rail makers in England, that puddled steel is a "material capable of resisting well the wear and tear of railway stock," but that the attempt to use it failed simply because "*solid blooms for rail sizes*" could not be obtained (by the present system). Now what I wish to submit to the notice of the makers of rails of this country is simply that having been engaged at a rail mill, at which semi-steel rails were made in large quantities, and occasionally puddled steel produced, I devised a plan by which *solid blooms*, up to half a ton weight, could be made of steel or iron direct from the puddling furnace; such blooms, after being formed in a mould and submitted to hydraulic pressure, can, with one "wash-heat" be rolled direct into rails without being allowed to cool from the puddling furnace to the finished rail. I also found that by the most simple process, part of the bloom could in the mould be transformed into tough fibrous iron; by this means the web and foot of the rail could be made fibrous iron, and the head fine granular steel. This is no theoretical idea, as I carried my trial to perfection at a considerable expense and on a sufficiently large scale previous to my obtaining my Letters Patent for the method. There, then, is the plan complete for producing puddled-steel or granular iron-rails from one solid puddled bloom. This does away with piling blooms for rails, and gives a solid rail of far more reliable strength than ingot rails. Therefore, to make the rails superior and reliable, they must have a granular head and fibrous web and foot. But as the best iron-rail cannot bear the heavy rolling stock of the present day without too much wear, steel rails are now sought for. There is no reason why puddled steel may not be made in the same furnaces, and with the same men, as iron now is, and there is no necessity for new and expensive plant. By a few trials a good puddler can, with a proper quality of iron, make steel with as much ease as he can produce puddled bar-iron, and thus, by adopting the system alluded to, steel rails could be turned out instead of iron rails.—*Bulletin of the American Iron and Steel Association.*

Steel Manufacture.—The difficulty of melting steel in sufficiently large mass for some purposes is well known, as by the ordinary processes, owing to exposure to the gases of combustion and other causes, much deterioration of the quality is almost sure to be the result. As a partial remedy, the metal is usually melted in crucibles, but these are expensive and require constant renewal, and when a large casting is to be made it is necessary to use a large number of them, and it is

difficult to regulate their temperature so that all shall be at exactly the proper melting point at a given time.

A German founder recently announced a method used by him, by which the difficulties mentioned above may be obviated, and steel in any quantity melted and cast as readily as iron. He dispenses with crucibles, and melts his steel in a hearth of burned fire clay, capable of containing 1,800 lbs. The furnace is so arranged that at the proper time a bellows can be brought into play so as to bring the heat to the melting point in a very short time, and thus avoid any continued strain upon the hearth. To protect the melted steel against the injurious influences of the gases of combustion, it is covered with a coating, 1 or 2 in. thick, of melted green bottle glass, or furnace slag, made on a charcoal iron furnace, great care being taken to exclude any sulphur. About 70 lbs. of glass or slag will be needed for every 100 lbs. of steel. If one hearth will not hold enough steel, several may be used. The melted metal is to be drawn off in the usual way into kettles, lined with clay, and transported to the mould for casting.—*Iron Age.*

BLAST FURNACES.—From a return recently published in "Ryland's Iron Trade Circular," of the blast furnaces in the various iron making districts of the United Kingdom, we abstract the following particulars.

Name of District.	Number of Blast Furnaces.		
	Number in Blast.	Number out of Blast.	Total.
South Staffordshire.....	102	72	174
North Stafordshire.....	27	10	37
Shropshire.....	21	8	29
West Coast.....	34	9	43
South Wales.....	111	87	198
Cleveland (about).....	101	14	115
Scotch.....	129	29	158
	525	229	754

Besides the furnaces above mentioned, there are in the Cleveland district eleven new furnaces now building, and in a more or less advanced state, while several of the Cleveland firms are rebuilding and raising old furnaces. Two new furnaces are in course of erection in the West Coast district.—*Engineering.*

COAL AND IRON IN THE "FAR WEST."—An interesting trial has just been made at the Union Pacific Foundry, Omaha, in the production of iron with coal from the territory of Wyoming. The result is said to have been very satisfactory, the iron being tough and strong, and with no trace of sulphur in its composition. It is thought that this may be the forerunner of many iron manufacturing establishments in Omaha, Nebraska and other portions of the Far West.

PREVENTION OF IRON RUST.—Dr. Calvert has communicated to the Chemical Society some very useful information on the rusting of iron. Rust is mainly sesquioxide of iron, and it has always been supposed that the active agents in producing it are moisture and oxygen. It seems, however, from Dr. Calvert's experiments, that carbonic acid must be associated with these to produce any considerable amount of oxidation. In dry oxygen, iron does not rust at all; in moist oxygen, but little and seldom; but in a mixture of moist carbonic acid and oxygen, iron and steel rust very rapidly. In like manner, a piece of bright iron placed in water saturated with oxygen, rusts very little; but if carbonic acid is present as well, oxidation goes on so fast that a dark precipitate is produced in a very short time. Curiously enough, bright iron, placed in a solution of caustic or carbonated alkali, does not rust at all. These facts show that the points to be attended to in the preservation of iron from rust are the exclusion of carbonic acid and moisture, two indications which may be very easily fulfilled.

RAILWAY NOTES.

ROCK ISLAND PALACE CAR "CALIFORNIA."—The dimensions and arrangement of this peerless car are the same as of the "Sacramento," 60 ft. long; lobby in each end, one containing a Baker Heater (enclosed in screen), toilet stand, water closet and wardrobe in the other, a baggage closet taking the place of the heater; state-room at each end of the grand saloon, accommodating 6 persons, with sofa, easy chairs, table, side light, mirrors, etc., 10 sections, in the body of the car, accommodating 40 persons, making the capacity of the car 52.

The chief novelty in exterior construction consists in the introduction of the Mansell wooden wheel, with steel tire—a wheel which, for elasticity, comparative freedom from noise, and durability, is likely to come into general use in the first-class passenger equipment of our best roads. The outer sides of the car are ornamented at each end with a bronze medallion, 2 ft. in diameter, of the California coat of arms—an exquisite piece of art; and the painting is of the same exquisite design and hues as that of its predecessors—the "tone" being harmonious with that of the interior decorations.

It is in these latter that we find originality and unexcelled beauty of design. The effect studied has been that of perfect harmony of tone between the wood-finish, the painting and the upholstering; and of an artistic *tout ensemble.* It is not merely that you have here in a space of 500 sq. ft. the varied and often meretricious ornamentation of an ambitious $25,000 city mansion. It is that the car presents, along with all the "modern improvements" of a first-class private house, the unity and harmony of effect of a master-piece of decorative architecture.

The ground-work of the wood-finish is mahogany; the panels are of purple-hued maple; the ornamental finish of the principal parts—arm chairs and sofas, around doors, mirrors, etc.—is of white holly, relieved with ebony piece-work, and set off with miniature medallions in gilt, a score or more gems of classic art. The ornamental work of the berths and raised roof is of original, unique, and beautiful design, which must be seen (as it is intended to be) to be appreciated. The centre-piece of the berth lining is a medallion—ground of black walnut, with bas-relief in white holly, of such *chef d'œuvres* of art as "Night and Morning," "Music," and other allegorical subjects. Starting from this centre, the lining is laid off in panels bound by various curves—these latter ebony, with gilt bands.

The head lining is in the same style—the patterns being varied. The colors of the ground are buff, in two or three shades, relieved with very delicate figures in gilt, red, and blue.

The upholstering is similar to that of the "Sacramento," the hues of the French moquette seats, of the Wilton carpets and of the berth and window tapestries, harmonizing with those of the walls and ceiling. At the upper corners of the doors are figures of Cupids exquisitely carved.—*The Iron Age.*

THE EXTENT OF RAILWAY IN OPERATION IN THE UNITED STATES.—At the commencement of 1870 there was, according to the best information obtainable on the subject, 48,860 miles. This total does not include 3,500 miles of street railways existing in Boston, New York, Brooklyn, and Philadelphia. In the course of 1869 no less than 6,588 miles of new railway were opened in the United States—viz., in the North-Eastern States, 254 miles; in the middle Eastern States, 1,030 miles; in the South-Eastern States, 186 miles; in the Gulf and South-Western States, 223 miles; in the Northern interior States, 3,977 miles; and in the Pacific States, 922 miles. The aggregate expenditure upon United States railways in 1869 was no less than $358,707,678, of which $189,000,824, related to the Northern interior States. The aggregate amount of capital expended upon United States railways to the close of 1869 was $2,212,412,719. The extent of railways in operation in the United States in 1830 was 41 miles; in 1835, 918 miles; in 1840, 2,197 miles; in 1845, 4,522 miles; in 1850, 7,475 miles; in 1855, 17.398 miles; in 1860, 28,771 miles; in 1865, 34,442 miles; and in 1870, 48,860 miles.

DEPTH OF RAIL SECTION.—The rail is practically nothing but a girder for supporting the weight of the train, and the stiffer it is at all points, the nearer it approximates in character to the bed of a planer, the better it will fulfil the conditions required of it. In using fish-plates the joint is always the weak spot, because there is not the requisite amount of metal to resist the vertical pressure. The common form of iron rail, with 3½ and 4 in. depth of section, has always been regarded as too shallow for proper fishing at the joints, and the best engineers have advocated a change. We are glad to learn that on the New York Central the managers have now adopted 4½ in. for steel rails and 5 in. for iron. These standard depths, with a proper arrangement of the fish-plates at the joints, and a proper arrangement of cross-ties, will be a great advance upon the common practice, giving increased steadiness to the movements of the train, and a consequent prolongation to the life of the rolling stock. We commend these standard depths of rail section to other managers as the proper ones for adoption, especially for all roads with any considerable amount of traffic.—*American Railway Times.*

UNIFORMITY OF GAUGE.—With a view to the establishment of a uniform gauge for railways throughout the United States, the following plan is under consideration by railway men and various members of Congress. Five-sixths of the roads already have the same gauge—say 4 ft. 8½ in. To bring the other sixth to this, as the easiest and cheapest plan, it is proposed that, after a given day, no road shall be a post road that does not conform to this gauge. The expense of changing a five-feet gauge to conform to this plan will not exceed $500 per mile, and it is believed that most of the roads could make the change at a less expense. As there are less than 8,000 miles of road requiring alteration, the whole cost of the work would not exceed $4,000,000. This sum would perhaps be saved to the country, by the change, in one year. As the United States are interested in having the most expeditious transportation of the mails and military stores, the public benefits to be secured, might, perhaps, justify an appropriation by Congress to make the change.—*Phil. Public Ledger.*

PENNSYLVANIA RAILROAD PASSENGER TRAFFIC FOR 1869.—We present an exhibit of operations in the passenger department more in detail than they were given in the reports hitherto published by the newspaper press:

Passenger Traffic of the Pennsylvania Central Railroad Company, 1869.

	No. Pass.	Miles.	Receipts.
First class....	4,200,607	134,930,814	$3,500,071 03
Emigrants....	28,756	9,797,838	131,065 93
Total.....	4,229,363	144,728,652	$3,631,136 99
Regular Express.....			181,995 00
Extra Express.....			120,659 54
U. S. Mail.....			118,961 91
Total earnings from passenger trains			$4,052,753 44

The gross revenue derived from first-class passengers and emigrants in 1868 was $3,610,148.23, and in 1869 $3,631,136.99, showing an increase of $20,988.76.

In the year 1868, however, there was included the sum of $107,777.63—money received for the transportation of Government troops in previous years. This sum, in making a comparison of the two years, should be deducted from the receipts for 1868. The result would show an actual increase in the first-class passenger business for the year 1869 of $128,766.39.

Of this increase there was from—

First-class passengers.....	$75,944 75
Emigrants.....	52,821 74
Total.....	$128,766 36

The number of through passengers between Philadelphia and Pittsburg in 1868 was:

1868	96,228
1869	124,830
Increase.....	28,602

The number of local passengers in 1868 was:

1868.....	3,650,950
1869.....	4,104,533
Increase.....	453,583

Included in this statement of the local passengers given, are all passengers coming to or leaving the road at points between Philadelphia and Pittsburg; also the passengers to and from New York, *viâ* Allentown, and those to and from Baltimore and Washington.

The total increase in the number of passengers carried is 482,185, and in miles 11,530,350—equal to an average distance of 34.22 miles, and equivalent to 407,686 through passengers, an increase of 32,479 over the previous year.

Of the 4,200,607 first-class passengers carried, 1,059,131 were of the "monthly coupon" and "school class," and of these and other local passengers carried, 1,860,199 travelled a distance of 7 miles.—*Chicago Railway Review.*

THE EUROPEAN RAILROAD SYSTEM.—A German paper has made the following calculation: A train composed of all the locomotives and railway carriages in Europe would reach from St. Petersburg to Paris, and would contain 400,000 passenger carriages and 500,000 luggage vans. The railways of Europe are carried over 62,000 large and small bridges, and go through 34 miles of tunnel. 150,000,000 cwt. of iron has been used for the rails, and 80,000,000 cwt. of coal is required yearly to feed the engines. The network of European railways includes all States except Greece, Lippe-Detmold, Waldeck, and a few other very small German States. It represents a length of 70,718 miles; 18,000 locomotives are employed on it; the distance these rush over during the year is 60,000,000 miles. If to this is added the distance passed over by passenger carriages and luggage vans, we get to 100,000,000 of miles.

SOUTH PACIFIC.—This road has been christened a variety of names. When controlled by the Pacific Road of Missouri (who built it as far as Rolla), it was the "Southwest Branch Pacific Railroad." When after its reversion to the State, Gen. Fremont got possession, it was called the "Southwest Pacific Railroad." Subsequently, on the failure of Fremont to carry out the terms of the charter, the road passed into its present hands (heavy Boston capitalists, who are eminently responsible men), it assumed its present title.

The progress of this road has been very satisfactory under the present *regime*. Sometime in November last we announced its completion and opening from St. Louis to Lebanon, 185 miles. Since then 15 miles more have been laid, and the Company confidently expect to get through tracklaying to Springfield (241 miles from St. Louis) by the 20th of April next, and reach Neosho, 50 miles further, by the 1st of July. One regular daily passenger and two freight trains now run to Lebanon, there connecting by stage to all southwestern points. The traffic is good, and returns for the past fiscal year indicate a profit of 50 per cent. Though the actual terminus of this road is Springfield, it is destined to be an integral portion of the great through line of the Atlantic and Pacific, *via* San Diego and Albuquerque to San Francisco. New lines also are contemplated and being built, which will intersect this line and add to its revenue.—*Chicago Railway Review.*

THE CENTRAL PACIFIC RAILROAD.—The courtesy of the officers of the Central Pacific—the California side of the railroad connection to Promontory in Utah—gave me, last evening, the pleasure of a ride on the engine *up* the Sierra and round Cape Horn, and to-day an opportunity, from the same point of observation, of enjoying the ride through the rock walls of Humboldt and Twelve Mile Canyon.

My thanks are due to Mr. Crocker and Superintendent Towne for the bit of pencilled paper by which I was enabled to enjoy one of the most delightful experiences of my life.

The real difficulty in the way of engineering, in connecting the two oceans, occurs on the western side. It is all plain sailing on the eastern till the road descends by a steep grade and through a pair of long tunnels into the Salt Lake Basin by Weber and Echo Canyons. The level plains of Nebraska, and the high table land of the Laramie Plains, by which the road ascends and crosses the Rocky Mountains, at an altitude of 8,000 ft., offered no difficulty to the engineer. The trouble on the Union Pacific was from the Indians—the warlike Sioux and Cheyennes—and from the fact of the great distance from supplies and material.

But on the western side, the engineering problem was the great one from the start.

Immediately after leaving Sacramento the ascent begins, and the problem was to ascend the Sierra Nevada range to a height of 7,000 ft. within a distance of 80 miles.

There was no getting round the thing. The mountains stood there barring the way eastward. They would not get out of the way for a railroad, and the "passes," by which travellers in the old time surmounted the obstacle, are all from 5,000 to 8,000 ft. at their height above the sea level.

It was, indeed, the common talk in California that it was impossible to carry a railroad up the western face of the Sierra. Even good engineers considered the undertaking preposterous.

It is easy enough to mount it from the east, for the high table land of the "great desert" comes up to its eastern side from 4,000 to 5,000 ft. In fact the Sierra Nevada is the western face of an embankment—the embankment being half a continent—and this, the guttered and storm-washed front of it towards the Pacific.

The point was to get up this rocky face to the table land it bounded, and to do that in a very short space, for the continent breaks off short and comes down sheer.

But California energy, using 10,000 patient Chinamen, solved the problem, and took the track up and over, along the mountain side, through deep and long tunnels, across rifted chasms in the rocks, over headlong torrents and by the dizzy edges of abysses thousands of feet down, and "around Cape Horn."

But even when the work was done, the snow avalanche or the earth slide from the mountain round whose side, half up, the iron path winds twisting upward, might sweep the work away, or overwhelm the track and make it useless for weeks or months.

There was a remedy also for this in the skill and determination of the men who did this work. They just roofed in their road for fifty miles!

They took the giant stems of the pines and braced them against the mountain side, framing them and interlacing them beam with beam. They sloped the roof sustained by massive timbers, and stayed by braces layed into the rock, and covered with heavy plank, up against the precipice, so that descending earth or snow would be shot clean over the safely housed track into the pine tops below, and so they run their trains in security under cover, and have conquered the snow in its own domain.

There is one drawback. These "snow-sheds" shut out forty odd miles of the most magnificent scenery on the whole trip—notably Donner Lake, and the deep valley enclosing it, which lies straight down below the passing trains.

It was up this slope I travelled yesterday afternoon and evening. It takes two locomotives to persuade the trains to ascend. I found a place

just after leaving Sacramento, on the foremost, and had a mountain ride, which I think must be unequalled considering the mountains and the horse.

First there was the Sacramento valley — oak opening all, which, to most of your readers, needs no description. Only the oaks are of a species not seen in Michigan or Wisconsin. California is rich in oaks, and these, scattered about as thickly as apple trees in an old orchard, are the live oak, small-leaved evergreen.

Then came the "foot hills" and a gradual change in the wood-growth. The Manzanilla wood, with its shining stem and dark-green glistening leaf, mingled with the oaks, and the buckeye, which, in California, is a many-stemmed bush, springing from a common root, hung heavy with its pear-shaped fruit, filling up the space beneath the taller oaks and the nut pines.

Finally, we came into the realm of the *coniferæ*, and the tall stems sprang up smooth, branchless, and tapering, rearing their green coronals to the sky.

We were going up the mountains! In a valley on one hand lay a mining village—the most beautiful villages in the State are these mining villages now. Down the mountain side, on the other, ran the water, led in sluices like a mill race, around a point here and a bend there, and across a gorge yonder—the water to be used under the mighty power its descent gives it to tear the hill side down and wash the rocks to pieces in "hydraulic mining."—mining that is which consists in discharging a stream of water, with a head of a few hundred feet, full in the face of a hill side till it is knocked into bits!—bits which contain gold, of course, or are supposed to.

But these too are left, as we go clanking on through pitch dark tunnels and over trestle works that look like spiders' webs, and along the maze of dingy precipices, the engine coughing and straining in the tug up the steepest grade yet ventured by any engineer.

The day died out before we reached the summit, but died into a cloudless moonlight so brilliant, so silvery white in the flood of light it poured across land and sky, that one sent no regrets after the sunset.

Moonlight in the mountains, and such a moonlight is something to be remembered for life. I lost all sense of the poor every-day world, forgot so vulgar a thing as a railway car, even the clank of the engine seemed to come softened as from far away, and I was sailing over pine-clad mountains, silvery white, in an air of balm and fragrance, and, in fact, I think was about half asleep when my friend, the engineer, plucked my sleeve—we were doubling Cape Horn!

Round the jutting mountain wall, so called from its bold advance into the valley, and its precipitous face, the road winds like a ribbon. No human foot had ever trodden this height, as far as man may judge, till the first "hand" was lowered down to lash himself to a tree and begin, with pick and spade and crow, to cut a shelf along the dizzy height! Not even an Indian trail had ever passed where the long train was passing now. The foot-sure savage had never ventured here. Three thousand feet sheer down lay the valley, in the moonlight, like a lake, the mist slowly rising and swaying, silvered by the descending light. The feathery tops of the rock-anchored pines rose out of the mist far below. Across the valley the other mountain face frowned darkly, shaggy with bristling pines from base to summit.

That was one side.

On the other rose the almost perpendicular wall of the mountain, round which we were rushing on a shelf cut into the rock wide enough for the rails, of course—what need of anything more, when they are treble-spiked, and the rolling stock of the best, and the engineer the safest man to be found?

If we went off? If a broken rail should be ahead, if a rock should have rolled down beyond the curve yonder? Well, I suspect it would not make much difference, in that case, whether one was on the engine or in a car yonder. It would amount to the same thing, I think, when we all reached the valley together.

But there has never been an accident, and it is just such places as this that are most carefully guarded, and where all prudence, and forethought, and skill are engaged to be active

I do not know that I have been able to give you half an idea of the magnitude of this undertaking, which has annihilated these weary desert spaces and brought East and West together. If I have said much about it, it is because, after all, looking at it as I have, it seems to me the railroad across the continent, the double iron bands that tie Omaha and Sacramento each together, over the mounains, across vast deserts where human life finds nothing to sustain it, through the territories of tribes, too, a few years ago a terror to the whole border—it seems to me the railroad is really the most wonderful thing one sees, after all.—*American Churchman.*

A Double bogie eight-wheeled 24 ton Fairlie engine, built for the Nasjo and Oscarsham Railway in Sweden, was tried on the 17th ult. on the Ring Railway of the Fairlie Engine and Steam Carriage Company at Hatcham, England. The engine was run round the curves of 50 ft. radius, at the speed of 20 miles an hour.

The New Chilian Line.—This land line is to start from Valparaiso, passing throug the capital, Santiago, Santa Rosa, and San Felipe, crossing the Andes at the mining town of San Juan; thence to Villa Maria, where it will join the line already established from Rosario to Cordoba, passing through Mendoza San Luis, and thence to Buenos Ayres, thus connecting the Atlantic and Pacific coasts of South America *via* the Cordillera. The contractors have been granted a subsidy of $3,000 by the Argentine Government, and it is to be completed within twenty months after the signing of the contract.

A Road Locomotive, Thompson system, has been recently experimented upon in Paris, of which the wheels were lined on their periphery with thick india-rubber bands designed to increase adhesion to the road. This answers well enough the intended purpose; but the question is, how long those bands will last, as they are very expensive, some $700 per machine.

ORDNANCE AND NAVAL NOTES.

The Moncrieff Gun Carriage.—An official trial of the wrought-iron carriage and platform, the first manufactured in the Royal Carriage Department, Royal Arsenal, Woolwich, for 12-ton rifle

muzzle-loading guns, from designs furnished by Captain Moncrieff, Edinburgh Militia Artillery, was made last Friday at the proof butts, Royal Arsenal, Woolwich, in the presence of a brilliant party of officers. The weight and dimensions of the carriage and platform were: Weight of gun, 12 tons 11 cwt. 2 qrs.; carriage, 2 tons 5 cwt. 2 qrs.; elevator, 7 tons 14 cwt. 1 qr.; ballasting elevator, 15 tons 1 cwt. 3 qrs.; platform, 9 tons 6 cwt. The total weight was thus 46 tons 14 cwt. The length of platform is 19 ft., and width 11 ft. The height of axis of gun in loading position, 7 ft., and in firing position, 13 ft. 3 in. The ammunition used upon this occasion was the test iron cylinder for a 9 in. Woolwich muzzle-loading gun, weighing 250 lbs., the powder was rifle large-grain. The platform on which the gun and carriage were mounted stood upon a horizontal platform of wood, two 1 in. iron plates being placed under each of the trucks of the Moncrieff platform. A balk of wood, to serve as a central pivot for the platform, was placed on an incline, one end against the middle transom, and the other end pinned down to the ground platform. The object of the balk was to prevent the movable platform from being carried to the rear on firing. Round 1.—Powder charge, 30 lbs.; projectile, 250 lbs.; recoil almost full. After firing this round two additional balks were placed, as the one before described, to prevent the anticipated backward movement of the platform. Round 2.—Charge, 40 lbs.; similar projectile as last; recoil all but full. In running the gun up after loading the third time the pawl of the rack on the right side of the carriage, from the want of attention or inexperience of the man who had charge of it, was allowed to fall into the rack when the gun was half way up, thus preventing the gun from going any further. The gun was worked back and the pawl removed from the rack. The pawl pin having been slightly bent, the pawl was altogether removed. Round 3 and last.—Powder charge, 43 lbs. (battering); recoil full and perfect. The recoil of the gun at this round acting on the timber balks doing duty as a pivot, caused a rebound forward of about half an inch of the Moncrieff platform, and all the weight upon it. The gun was under complete control throughout the experiment; the recoils were not at all violent. All parts acted with perfect success. We understand that the carriage and platform will now be forwarded to Shoeburyness, to be placed in the hands of the troops at the School of Gunnery for a more extended trial. The result of the experiment is considered highly satisfactory.—*London Times.*

THE "STUART" BREECH-LOADING CANNON.—Although experience thus far has demonstrated the extreme unreliability of breech-loading artillery in active warlike operations, their invention and trial is still a matter of much interest and attention to projectors of new forms of military implements and enginery. The following is a description of a new English breech-loading cannon, which was lately brought before the "United Service Institution" (London) in a paper read by the inventor, Captain Graham Stuart. One of the guns has withstood the firing of 100 rounds, and it is understood that a 300-pounder on the same plan will soon be constructed at Woolwich Arsenal:

"An ordinary gun forging, somewhat enlarged in the internal diameter of the breech, is bored as usual, but the part of the boring in the breech is made 2 or 3 times as large as the remainder. Into this a sphere of metal, perforated as the bore, is introduced. One face of this has a *spiral* perpendicular projection. This fits against a bronze expansion ring fitted into the rear end of the bore, and acts as a wedge, completely sealing the breech. This sphere is mounted on gudgeons, which pass through the sides of the breech, and is turned by handles outside the gun. It rotates on its axis a quarter of a circle to open or close the breech. The perforation being accordingly in a line with, or at right angles to, the bore, the sphere rests against a heavy perforated breech plug screwed into the solid breech. Through this the charge is introduced; the operation of opening and closing is easy and expeditious; so much so that, whereas an Armstrong gun requires 10 men to work it, this gun can be worked with 8. The openings in the breech being the smallest possible consistent with breech-loading, strength is secured. The simplicity is evident from the fact that there are only 3 principal parts of the breech concerned in resisting explosion and force, namely: the plug, ball, and expansion ring. The prevention of gas escape is completely obtained. In the course of repeated trials this has been carefully tested; but none has been observed. Other advantages are the absence of openings into the sides and top of the breech, and the rapidity of fire attainable. The inventor has fired 6 rounds in 35 seconds, equal to 10 rounds per minute. The gun will stand hard work and rough usage. It was left without cleaning for several days, and at the end of the time the breech was opened without difficulty."

AMERICAN SMALL ARMS.—Breech-loading rifles are about to be substituted in the United States Navy for the muzzle-loading rifles still in use in that branch of the service, the ships' companies and marines being supplied with similar weapons. On the 29th of March last, the naval bureau at Washington instructed a commission appointed for the purpose to make an examination of the best system in use, and to test them thoroughly for endurance, convenience, and efficiency.

In accordance with these instructions, the committee invited the submission of different designs of breech-loaders that should conform with the specified regulations. Fifteen different arms were forwarded for the inspection of the committee. These were divided into six classes: the lever system, with perpendicular sliding breech block, the bolt and horizontal sliding block, the bolt and hinged block, the combination of bolt, ratchet and lever, the swinging or hinged block, and the Remington system, wherein the breech block is pivoted below the level of the chamber, and which does away with lever and bolt. It is this latter system which the committee, after exhaustive trials, though by no means so thorough and exhaustive as were conducted by our own small arms committee, ultimately decided upon adopting. To the breech mechanism has been added the Springfield barrel calibre .50. With regard to the cartridge, that in extensive use in the United States Army has also been recommended for the Navy. The powder charge is 70 grains, the weight of bullet 458 grains, and the cartridge is enclosed in a copper case, provided with central fire, tallow, and beeswax lubricant, and a cardboard wad between bullet and powder. The best form of cartridge was, however, found in the course of rapid and long sustained fire, to produce more or

less leading on the barrels, unless paper patches were wrapped around the bullet, and the final determination as to this detail of the cartridge has been postponed until experience has been gained as to whether such patches would deteriorate in quality during a voyage.

It is time that the United States should take action in the matter of an improved small arms equipment, but it is a pity that the labors of the committee appointed were so brief, for otherwise they would probably have secured a better arm for their service, just as with us a long period was requisite to bring the Martini-Henry to perfection. —*Engineering.*

NEW GUNPOWDER.—A new kind of gunpowder has been prepared by M. Brugére, by mixing 54 parts of picrate of ammonia with 46 parts of nitrate of potassa. The mixture produces, on burning, 10 atoms of carbonic acid, 6 of nitrogen, 6 of hydrogen, and as a solid residue, 2 of carbonate of potassa. The following are the advantages over ordinary powder, as claimed by the inventor: It is more homogeneous, and its effects are consequently more regular; it is far less hygroscopic; it is more effective for equal weights; and it leaves far less solid matter on combustion. The residue left after combustion does not affect metals, since it is only carbonate of potassa. This powder hardly emits any smoke at all, and what little is emitted is devoid of smell. The author recommends a mixture of 25 grammes of picrate of ammonia, 67 grammes of nitrate of baryta, and 8 grammes of sulphur as an excellent substitute for Bengal light, and as suitable for signal and port lights and use in theatres, since hardly any smoke is emitted and no unpleasant smell given off, while the light is very brilliant, slow burning, and yields a beautiful greenish tinge.

ENGINEERING STRUCTURES.

EAST RIVER BRIDGE.—The caisson for the Brooklyn pier of the East River Bridge was successfully launched on the morning of the 18th of March. A large number of engineers were in attendance.

THE LAST PROPOSAL FOR UNITING ENGLAND AND FRANCE.—A French Engineer, M. Eugene Burel, has been in England to explain his plan for shortening the distance between England and France. He has nothing to do with bridges over the sea, or tunnels under it, but would simply improve it off the face of the earth; in other words, fill up the channel on both sides, and reclaim the land, leaving only a passage a mile wide to be traversed by ferry-boats every five minutes. M. Burel is a grave, serious gentleman, and really believes in his scheme, whatever our readers may think of it. They may like to hear him speak for himself, and this is what he said on the subject the other night at the dinner of the Society of Engineers, when he returned thanks as a visitor. "My scheme," said he, "is for neither a tunnel nor a bridge; it is the old mother land restored from the sea as it was seven thousand seven hundred and twenty-four years ago. Allow me to add one new county to England and one department to France across the channel, and thereupon to establish a railroad. By the time this will have been accomplished, with the increase of speed that will be attained I will make you go from London to Paris in five hours. I do not wonder that you laugh at the first communication of such an idea; for some of our master engineers said to me, in the similar instance, that this was a folly a little worse than the other proposition to the same end.

"However, I want you to think of it, and not to be too hasty in decreting the impossibility. One thing is in my favor, and that is the numerous examples of such restorations of land, although on a minor scale; and it requires nothing but a combination of the most approved systems of *assisting nature* (as your celebrated engineer, Telford, said), to accomplish this, at first, extraordinary looking work. Some say that England would never admit of being altered from its present situation of an insular land, to which she considers she owes her independence and her supremacy on the seas. I will not discuss now any political question, although I consider the unlimited increase of the means of communication between all the nations of the world to do the best some day or other, and set at rest every bit of unworthy consideration of this kind, especially when time will have still more proved the benefit of the general union of the trades and commerce between all nations.

"But I will say one thing, and that is, that assuming the isthmus to be still there as it was formerly, before the Diluvium Cimbricum, as reported from ancient traditions by Florus, and demonstrated by all the geological transactions, we should have to call M. de Lesseps to bore it, as there should be still a greater need of his scheme there than at Suez. Now, under such considerations, I would restore the land, not completely, but only so far as to leave a narrow channel one mile wide in the middle, and thus both the free circulation of the seas and the political question would be safe. In fact, my solution of the difficulty is a solution of contiguity. You say one mile is too little; I answer—No, it is not; for, I do not care whether it be one or twenty miles, when I think of the ferry-boats that are spoken of for the next year, which will be able to transport an army, or when I think of the guns that will soon afford us the possibility of firing against each other without parting from our shores. Had we not better advance at once, facing kindly to each other, so near as to shake hands over the water, while the ferry-boats would cross it every five minutes, transporting backward and forward all the treasures of our industries?"

With the best possible feeling, we advise M. Burel to waste no money on the prosecution of his scheme. We will not venture to say what changes in opinion may take place one of these days, but at the present moment England has no desire to give up her insular position.—*The Builder.*

FRENCH PUBLIC WORKS.—During the last seventeen years, under the regime of the late Prefect of the Seine, the city of Paris has expended on extraordinary works alone no less than 2,117,500,000 of francs, or £84,700,000 sterling, of which amount upwards of half, or £43,800,000, has been raised by loan, the remainder having been defrayed out of the ordinary municipal revenues. The interest on the sum borrowed is upwards of 46,000,000 francs, besides which another 10,500,000 is applied towards a sinking fund, and a further 10,000,000 by way of annuities. It results from this, remarks M. Lannau-Roland, who has furnished the forego-

ing figures to the "Patrie," that the rebuilding of Paris by Baron Haussmann, so far as it has gone, has imposed upon the city an annual burthen of 67,000,000 francs, to be reduced to 57,000,000 when the annuities have all fallen in; but, on the other hand, the annual revenue during the progress of these works has gradually risen until it has attained the high figure of 171.000 francs, which is not only sufficient to provide for all these charges, but leaves 37,000,000 francs (about 1,500,000 sterling) at the disposal of the municipality for new undertakings.—*Engineering.*

THE MONT CENIS TUNNEL.—During the past year an advancement of 1,431 45 metres has been made at the Mont Cenis Tunnel: of this, 827.70 metres were driven on the Italian side, at Barronneche, and 603 75 metres on the French at Modane.

The following shows the monthly progress made during 1869:

	Progress made at		Total Advancement made during Month.
	Bardonneche.	Modane.	
	metres	metres.	metres.
January	50.90	56 45	107.35
February	60.60	31.75	112 35
March	81 90	54.05	135 95
April	76.75	48 25	125 00
May	71.90	53.70	125.60
June	70 55	45.30	115.85
July	69.10	50.90	120.00
August	68.40	58 25	126.55
September	72.80	58.15	130 95
October	76.40	47 50	123.90
November	66.10	41.95	108.05
December	62.30	37 50	99 80
Lengths driven during 1869	827.70	603 75	1,431.45
Lengths driven previous to 1869	5,363.10	3,803 70	9,166 80
Total lengths driven	6,190.80	4,407.45	10,598,25
Remaining to be driven.	....	....	1,621.75
Total length of tunnel	....	....	12,220.00

The total length of tunnel *completely finished* on 31st December, 1869, was as follows:

	metres.
South side (Bardonneche)	5555.20
North side (Modane)	3669 75
Total	9,224.95

The average monthly progress during the past year was 119.28 metres, or 68.97 metres on the Italian side, and 50.31 on the French side; and at this rate of progress, the time necessary to complete the tunnel would be less than thirteen months, or about the end of January, 1871, and for opening the railway about six months later, or in about a year and a half from the present time.—*Engineering.*

SINKING SCREW PILES.—A machine has been lately designed by an English firm at the request of H. Lee Smith, Esq., chief engineer for the Punjaub Northern Railway, for screwing down piles to be used in constructing bridges and flood openings on that line of railway. This machine consists of a wrought iron under carriage mounted upon wheels of 5 ft. 6 in. gauge, and carrying a vertical power at one end. A strong cast iron beam in the centre carries a cylinder in which works a ram, to the top of which a strong cross-beam is bolted which carries the machinery for operating on the piles. This consists of a horizontal steam-engine bolted to the side of the cross-beam, and driving a pinion and train of spur and bevel wheels which impart motion to two large horizontal wheels carried in bearings at each end of the cross-beams. A friction clutch is carried in the centre of each of the wheels, through the boss of which the shaft of the pile to be screwed is passed. The shafts are rolled with feathers or ribs on each side, which, passing through corresponding recesses or keyways formed in the boss of the friction clutch, form the means of imparting motion from the horizontal wheels to the piles; steam is brought from the boiler, through the centre of the ram and cylinder which carries the cross-beam, by means of a telescope joint, which allows the ram to be raised without interfering with the steam pipe; and a small donkey engine is provided which can pump from a tank situated between the frame, either into the boiler or into the cylinder under the ram which carries the cross-beam. When the machine is at work the cross-beam is held firmly by means of cotter bolts to the frame. The modus operandi is as follows: A temporary road being laid on the centre line of the proposed structure, piles are pitched by passing the shafts through the wheels on each side of the machine, and keying them into screws which are placed in a small hole excavated to receive them. The engine is then set to work, and the piles screwed down as far as possible. The cotters holding the cross-beam are then removed, and it is raised by the donkey engine pumping into the cylinder of the machine, and lifted off the piles. The machine is then moved forward to the centre line of the next pile, and the operation takes place as before.—*American Railway Times.*

TEHUANTEPEC CANAL—The Minister of the Department of Public Improvement, Colonization, Industry and Commerce of Mexico, has transmitted to the Congress of that Republic a letter, containing the draft of a law authorizing the Tehuantepec Railroad Company to build a ship canal in addition to its railway across the isthmus. Surveys are to be made in 5 years and the plans must be approved by the Government. The construction of the canal is to be commenced within 3 years after the approval of the plans. The right of way and large grants of land are made in aid of the enterprise; the machinery, tools, coal and articles of prime necessity for the use of the employees are to be imported free of duty; the capital invested in the canal is to be free from contribution and taxation and no transit tax is to be levied. Various other important privileges are granted, but certain clauses would seem to place the stockholders at the mercy of the Mexican Government. The objectionable sections of the proposed law provide that "all persons now or hereafter engaged in the enterprise are to be regarded as naturalized Mexicans, and cannot bring forward claims as foreigners," and also that "controversies concerning the construction of the grant and the execu-

tion of the law shall be decided by Mexican tribunals." The Minister of Public Improvement recommends the granting of the application by the Tehuantepec railway, and asserts that explorations already made demonstrate that the Isthmus of Tehuantepec presents less difficulties than the Isthmus of Darien, to which the attention of the United States is now directed.

THE AUSTRIANS AND THE SUEZ CANAL.—The "Pall Mall Gazette" says: "Though the Austrians were confident in their assumption that the opening of the Suez Canal must redound to their commercial advantage in a degree which admitted of no rivalry by any other nation, the first instance of their profiting by this new route to India, is scarcely a fulfilment of their sanguine prediction. The screw steamer Apis, belonging to the Austrian Lloyds Company, of 1,200 tons burthen—a first-rate vessel, whose departure for Bombay was largely and widely advertised—sailed with a cargo of 130 tons! As the tariff fixed by the company is £3 10s. per ton, while the vessel pays a toll of 12,000 francs (£480) to the canal, and consumes 400 tons of coal on its voyage of 21 days, this beginning is surely not encouraging. Nor is the fact the more cheery that nearly one-half this small cargo was contributed by Venice. The company are evidently not deterred by this one experience, for they have now advertised the Sphynx, to sail 4 weeks hence."

THE HOLYOKE DAM.—The work of rebuilding this immense structure across the Connecticut river has been resumed. The dam is 30 ft. high and 1,018 ft. in length between the abutments. The fall of the river in the distance of ¾ of a mile is 60 ft., and the nature of the ground and the copious supply permits the water introduced into the canal to be used more than once. The preparations for carrying on the work have been very extensive. Two large flatboats and a new steamboat, 53 ft. long and 13 ft. beam, with engines of 20-horse power, are in progress of construction, to be used on the pond for the purpose of moving stone and materials necessary for the dam construction. A large boom is building, to hold 500,000 ft. of logs, to be sent down the Connecticut river. As soon as the water falls sufficiently, from 200 to 300 men will be put on the work.

THE FALLS OF ST. ANTHONY.—We read in the Philadelphia "Ledger:" "The mill seats on the Mississippi river, at Minneapolis and at St. Anthony, are arranged according to a novel device in hydraulic engineering. The bluffs of the Mississippi are composed of a stratum 14 ft. thick of limestone, supported by a layer of soft, white friable sand-stone. As the result of this formation, the Falls of St. Anthony have changed greatly within the last sixteen years. In 1854, the natural dam at this point was formed by a rocky ridge 16 to 18 ft. high, and the stream below was filled with immense blocks of limestone, which had fallen down from the ridge and the bluffs by reason of the washing out of the sandstone. This work of undercutting the limestone rock has been going on continuously, and the dam has been retreating up the stream. In order to prevent the further destruction of the Falls, the people of the town of Minneapolis, on the west bank, have commenced building an expensive protecting apron across the face of the Falls, and to facilitate the work a temporary side dam has been constructed with a sluice, which carries off the water in rushing rapids, leaving the ridge of the natural fall dry. East of this ridge is an island dividing the main stream from the little fall on the east bank.

"The Mississippi river at this point has a descent of 70 ft. to the mile, and furnishes water power in great abundance. The water is supplied to the mills by canals fed from above the dams, and the tail races for the discharge of the water after it has passed the mill-wheels, are constructed on a novel and ingenious plan. A well or shaft is sunk through the overlying earth and limestone down to the sandstone, and a tunnel is excavated to the river bank below the Falls. The sandstone, it is asserted, yields as readily as sand to the picks of the workmen, and tunnels several hundred feet in length have been constructed. The shaft serves as a water-wheel pit. This description, the main points of which are taken from the "Atlantic Monthly" for March, explains the hitherto unintelligible despatch received last summer in reference to the tunnel which was excavating beneath the limestone bed of the Mississippi river below the fall, for the purpose of opening a water power for Nicollet Island. The workmen struck a fissure in the limestone rock, and the Mississippi commenced discharging through the tunnel, and threatened to destroy the Falls of St. Anthony. The vigorous and protracted exertions of the workmen, however, were successful in preventing such a disaster."

THE CLEVELAND LAKE TUNNEL.—Cleveland, Ohio, tired of her nauseous water, is imitating Chicago in the construction of a Lake tunnel, wherewith to obtain the requisite supply of unpolluted liquid. The work—which when completed will consist simply in a shore shaft sunk to the proper depth, a tunnel extending out a mile and a quarter into the lake, and a vertical shaft and crib at the outer end, with inlets for the admission of the water—is being carried on under considerable difficulties. The mining is a tedious process, as there is only space for one man to work. The instrument used is a pick, with a bit nearly as broad as an adze. The clay is so strong and adhesive that by the most vigorous blows of the miner only little fragments are chipped out as large as a man's fist. The work progresses night and day, the miners working by reliefs the entire 24 hours. Not a particle of natural light penetrates that dark cavern, and night and day are the same, the watch being the only means by which to note the flight of time. Next spring the crib will be placed in position, and the outer shaft sunk, so that the work can be carried on simultaneously at both ends of the tunnel.—*American Artisan.*

NEW BOOKS.

OSBURN'S METALLURGY.—The review of this work contained in our March number should have been credited to the "Nation."

AN INTRODUCTION TO SCIENTIFIC CHEMISTRY, DESIGNED FOR THE USE OF SCHOOLS AND CANDIDATES FOR UNIVERSITY MATRICULATION EXAMINATIONS. By S. F. BARFF, M.A., Assistant to Dr. Williamson, Professor of Chemistry, University College, London. Second Edition. London:

Groombridge & Sons, 1869. For sale by Van Nostrand.

This is a well-written text-book on the non-metallic elements, excepting, according to custom, all but a few of the simplest carbon compounds. The four elements, hydrogen, oxygen, nitrogen, and carbon, are first described; then some of their compounds with each other; then the halogen elements and compounds; lastly, sulphur, phosphorus, boron, and silicon. They are described without the use of symbols, which may be an advantage on the whole; but as the value of symbols is so very great when we advance a little in our studies into deeper matters, they have to be learned, and we are not quite sure that it would not be simpler to make use of them from the first. At the same time, there is one important objection to their early use, which is that they are then apt to make the facts they are intended to express less thoroughly appreciated by the student than they would be if he had constantly to come into direct contact with them.

In a second part of the work the author goes over his ground again for the purpose of giving these symbolic expressions, and at the same time extending the treatment of each subject.

The nomenclature adopted is, as we might have expected, that used by Dr. Williamson; it is therefore, in one particular and important instance, not that in general use by other eminent chemists. We refer to the use of the word "acid." The oxides of an element capable of uniting with the oxide of a more basic or electro-positive element are the bodies described in this work as "acids.' The more general practice is to call by this name such bodies as the essential ingredient of spirits of salt, aquafortis, vinegar, oil of vitriol, because they *are acid*, as every one admits. Mr. Barff himself, indeed, speaks of "hydric chloride" (hydrochloric acid) as an *acid body* (p. 73). We do not intend, however, to press the point against him; the application of the term is a matter on which distinguished chemists are divided, and for our own part we think that the use of the term with any rigidly fixed signification might well be dispensed with, as it is not really wanted.

As an example of the style in which the work is written, we give a paragraph on the preparation of chlorine for general purposes:—

"Chlorine is usually prepared from one of its compounds called hydric chloride, which contains it united with hydrogen. This body has powerfully acid properties; it turns blue litmus paper to a bright red, and is commonly called hydrochloric acid. Many years ago it was called by chemists muriatic acid, and by common people then, as well as now, spirits of salt, but its correct name is hydric chloride. When hydric chloride is heated with a substance which can take away its hydrogen, chlorine is of course set free. The substance used for this purpose is black oxide of manganese (properly called manganic binoxide), which contains the metal manganese and oxygen. The oxygen of the manganese takes the hydrogen of the hydric chloride and forms water, setting its chlorine free, half of which at the moment of its liberation unites with the manganese, forming manganic chloride, and the other half escapes, and can be collected as free chlorine; 146 grammes of hydric chloride require 87 grammes of manganic binoxide for their decomposition: that is, 146 parts, whatever be the weight of a part adopted—whether grammes, grains, pounds, or ounces—require 87 parts of the same weight for their per-decomposition."

We can only add that we find this little treatise as sound in its treatment of the science as it is clear in its description of the facts, and we are not therefore at all surprised at the success it has already had.—*Scientific Opinion.*

A Treatise on Ore Deposits. By Bernhard von Cotta, Professor of Geology in the Royal School of Mines, Freiberg, Saxony. Translated from the second German edition, by Frederick Prime, Jr., Mining Engineer, revised by the author. 574 pages 8vo, with numerous illustrations. D. Van Nostrand, Publisher.

Professor Bernhard von Cotta, of the Freiberg School of Mines, is the author of the best modern treatise on ore-deposits (*Erzlagerstættenlehre*); and we are heartily glad that this admirable work has been translated and published in this country. The translator, Mr. Frederick Prime, Jr., a graduate of Freiberg, has had in his work the great advantage of a revision by the distinguished author himself, who declares in a prefatory note, that this may be considered as a new edition (the third) of his own book.

The changes in matter are quite numerous, and sufficiently important to make it advisable for those who possess the latest German edition to obtain this also. It is true that many of them are merely omissions; but these are, in some cases, of positive value, as, for instance, where the sections on certain supposed distributions of rich ores in regular zones have been struck out, as no longer supported by facts. We are not so well pleased to miss the chapters on prospecting and tracing ore-deposits, though these were meagre, and the work of Professor Gaetzschmann on that special theme (which by the way, ought to be translated next) is far more satisfactory. On the other hand, much has been altered or added throughout the book, in order to conform it to the latest results of foreign science and experience. As it now stands, it is calculated to do much good in this country, by clearing away a deal of rubbish from the field of this subject, and sowing the seeds of common sense and scientific accuracy.

Mr. Prime's work has been performed, on the whole, with skill and fidelity. We deem it a serious defect in his plan, that he resolved to reproduce merely the treatise of von Cotta. The work could be made more valuable by thorough transformation, and the substitution of American examples and illustrations. We trust that Mr. Prime himself may hereafter be moved to complete the good work he has begun, and really edit, as well as translate, the book before us. It is a stout, healthy stock, and will bear a graft of American science.

We notice some faults of translation, which we shall be so ungracious as to point out, since they can easily be corrected in the subsequent edition, which we hope will soon be called for. They are mainly infelicities or inaccuracies in the substitution of English for German technical terms. Our languge scarcely possesses a settled nomenclature of mining, still less of the science of ore-deposits; and in reproducing treatises from so rich a vocabulary as the German, it is necessary frequently to coin new words. But we ought to imitate the Germans in adopting the current miners' terms, wherever it is possible; and certainly we should not misapply terms which have al-

ready a fixed meaning. Mr. Prime's translation of *Drusenraum* (as applied to a cavity or space in a lode, lined with crystals) by *geode* instead of *vug*, strikes us as unfortunate, to say the least. The latter word would exactly express his meaning, while the former more properly describes a nodule or boulder containing such a cavity. We must question also the use of the word *fluccan*, to mean a cross-course, or cross-vein. The universal usage in this country applies this term only to softened, decomposed rock or clay, such as frequently occurs on the walls of veins. On the other hand, little use has been made of numerous American terms, already familiar to our mining population, and often exceedingly appropriate and forcible. Such names as spur, casing, gouge, hill-deposit, cement-deposit, gulch deposit, prospecting, and many others, are worthy to be retained. We confess to an affection even for the humorous and descriptive phrase, to "peter out," as applied to the contraction and final disappearance (*auskeilen*) of a vein. We should prefer width or thickness to breadth, which has been chosen by Mr. Prime to designate this dimension (*Mæchtigkeit*) of a fissure.

But we need scarcely say that these suggestions are not intended to detract from the really sterling value of this treatise. It is a timely and welcome contribution to the literature of mining in this country; and we are grateful to the translator for his enterprise and good judgment in undertaking its preparation, while we recognize with equal cordiality the liberality of the author in granting both permission and assistance. Bernhard von Cotta needs no new laurels from the paths of science; but those which he wears already derive added grace from the genial sympathy with which he extends a hand of help and encouragement to his younger co-laborers and scholars. Every student at the Freiberg school regards with enthusiasm, and every graduate remembers with gratitude, the fraternal interest in his progress manifested by the distinguished men who constitute its corps of instructors; and among them none is more beloved than the brilliant author of the "Gesteinslehre," "Geologische Briefe," "Gangstudien," "Geologie der Gegenwart," and "Erzlager-stættenlehre."—*The Engineering and Mining Journal.*

A Short Course in Qualitative Analysis, with the New Notation. By J. M. Crafts, Prof. of General Chemistry in the Cornell University. 133 pp. 12mo, with 5 Tables. N. Y., 1869. (J. Wiley & Son.) For sale by Van Nostrand.

Prof. Crafts is well known to our readers from his frequent valued chemical contributions. He has, in the small volume before us, attempted the solution of a problem which every chemical instructor must meet whose duties call him to impart to a mixed class of academic students a maximum of knowledge in a minimum of time. A considerable portion of the first two chapters is devoted to an explanation of the theory of chemical reactions and nomenclature. The student is at once inducted into the notions of modern chemistry and familiarized with atomicity and the present chemical nomenclature. It is certain that under a good teacher any faithful student will master the main points of qualitative analysis by the time he has gone through the second part of this useful little volume. Only 34 of the 64 radicals known to chemists are treated of in this book. This brevity sometimes mars symmetry and renders the work of the student almost too simple, as when, for example, strontium is left out of group II. The Tables IV and V, intended to record in a compact form the facts of analytical chemistry, are ingeniously devised by Mr. Perkins, to give the student exact ideas and methodical habits.—*American Journal of Science.*

On Aniline and its Derivatives. A Treatise upon the Manufacture of Aniline and Aniline Colors. By M. Reimann, P.D., L.A.M., to which is added, The Report on the Coloring Matters Derived from Coal Tar, Shown at the French Exhibition, 1867; by Dr. A. W. Hofmann, F.R.S., MM. G. de Laire and Ch. Girard. The whole revised and edited by William Crookes, F.R.S., &c. 8vo, pp. 164. (John Wiley & Son, Astor Place, New York, 1868. For sale by Van Nostrand.

Dr. Reimann's account of aniline and its derivatives is a fine example of the union of exact science with practical skill, and, as such, teaches an important lesson beyond its special theme. It could not have had a more valuable supplement than in the admirable report of Dr. Hofmann and his associates, on the coal tar colors shown at the French Exhibition of 1867. The book, though published by Messrs. Wiley, was printed in London, by Mr. Crookes at the office of the "Chemical News."—*American Journal of Science.*

Exercises in Practical Chemistry. By A. G. Vernon Harcourt, M.A., F.R.S., Sec. C. S., and H. G. Madan, M.A., F.C.S. Series 1st, Qualitative Exercises. 335 pp. 12mo. Oxford, at the Clarendon Press, 1869. London: Macmillan & Co. For sale by Van Nostrand.

This little volume is designed as the beginner's *vade mecum* in commencing the study of practical chemistry in the laboratory. No attempt at a systematic presentation of the elements of the science is here made. The novitiate is presumed to be equally innocent of nomenclature, symbols and philosophy, and is led into the laboratory much as an apprentice to a trade, and is therefore first made familiar with his tools, and how to use them in the most simple operations before even attempting the preparation of oxygen and other gases. It is illustrated by 65 wood-cuts, mostly new and many of them very effective. The nomenclature is that of Williamson. Symbols expressing the more important reactions are given at the foot of the pages where needed. We look with interest for the second series on quantitative chemistry.—*American Journal of Science.*

Civil Engineering and Public Works.—Paris Exposition of 1867. By Wm. P. Blake, Commissioner of the State of California. Washington: General Printing Office. For sale by Van Nostrand.

This is the title of a report published in the series of reports of the United States Commissioners to the Paris Universal Exposition of 1867. It is an octavo of some fifty pages prepared by Prof. William P. Blake, Commissioner of the State of California, and contains interesting notices of the extent of the exhibition made in that class; of materials for construction; a description in detail of the Chicago Lake Water Tunnel, illustrated by two plates; a description of the Suez Maritime Canal, and other miscellaneous notices.

ANNUAL OF SCIENTIFIC DISCOVERY, OR YEAR-BOOK OF FACTS IN SCIENCE AND ART FOR 1870. Edited by JOHN TROWBRIDGE, S. B., Assistant Professor of Physics in the Massachusetts Institute of Technology, aided by SAMUEL KNEELAND, M. D., Professor of Zoology and Physiology in the Institute and W. R. NICHOLS, Graduate of the Institute. Boston: Gould & Lincoln. For sale by Van Nostrand.

The "Annual" has so far become a necessity to the general scientific reader that the bare announcement of its appearance is sufficient to insure a lively demand for it. The present volume is embellished with a fine portrait of Prof. Peirce, the Superintendent of the Coast Survey.

MISCELLANEOUS.

SOLUTIONS FOR HARDENING STEEL.—A page might be filled with the record of all the preparations, mixtures, charms, etc., by the use of which success in the tempering of steel has been attempted, and each of which has had its admirers.

A certain virtue has been, by many, supposed to reside in leather shavings, by which, if a tempering fire *be kindled* with them, immunity from cracking is secured; and Byrne states that a man who had tried it told him that, although before its use he was greatly troubled by cracking while tempering, since he had found out the virtues of leather as a preventive not a single case of cracking had occurred, though he had used it for years.

Argument, of course, would be useless with such an individual; his experience (*sic*) would weigh with him more than anything that could be said by any one else, though the experience of the latter might have shown the utter worthlessness of the article in which the former placed blind and implicit faith.

The state of things which we have described is scarcely to be wondered at, when we reflect that all knowledge on the subject of hardening and tempering steel is empirical. Nothing is accurately known about it except that when steel is heated and suddenly cooled it becomes hard and brittle, and that by heating it again its hardness and brittleness may be reduced to the degree required, and that this change of character is a molecular change of some kind yet to be determined.

The suddenness of the cooling is of course affected by the rapidity with which the cooling medium conducts or conveys away heat; and any change in the character of the medium which does not increase or diminish its conducting power would certainly seem to have little to support it. Of course, the character of the objects to be tempered will indicate in some measure the mode employed. The watchmaker often heats his tiny drills in the flame of a candle, hardens them by sticking them into the cold tallow, and draws the temper by the same flame.

A little salt thrown into the water employed for tempering is quite generally supposed to add to its virtues, but a competent experimenter informs us that in a large number of experiments instituted to test the truth or falsehood of this notion, he found nothing to support it.

Thin and small objects, which only need a small degree of hardness, may be advantageously hardened in oil, for the reason that it cools them less suddenly, and therefore does not make them so hard as water would, while for large articles requiring to be very hard, quicksilver has been employed with success for precisely the opposite reason.

A recipe for hardening mill picks, which, slightly varied in its proportions, has quite a reputation, is as follws: 2 gallons rain water, 1 ounce corrosive sublimate, 1 ounce sal-ammoniac, 1 ounce saltpetre, and 1½ pints of rock salt. The picks to be heated to a cherry red and hardened, and the temper not to be drawn. It is claimed that the salt gives hardness, and the other ingredients toughness to the picks; but no reason why they should do so seems tenable, as there certainly is no chemical reaction in the bath by which these results can be accounted for.

We hazard the opinion that simple water would be just as good, and that for all moderately sized articles it is just as good as any solution that can be made, though of course in a matter depending so much upon personal judgment as the hardening and tempering steel, we should not expect any man to succeed perfectly at first with any bath to which he had not become accustomed.—*Scientific American.*

PUNCHING METALS.—General Morin presented to the Academy of Sciences of Paris, at their session of January 3d, a paper upon the punching of metals and plastic materials. He says:

We have proven by the results of numerous experiments in punching, made upon lead, that the characteristic co-efficient of pressure per square metre is exactly equal to the resistance to shearing per square metre; and from this theory we have deduced the formula,

$$L = R_1 \left(1 + \log^1 \frac{R}{R_1}\right)$$

in which R is the radius of a cylindrical block,
R_1 " " the punch,
L the length of "

This geometrical function contains no term depending on the height of the block, and in this general form no hypothesis as to the nature of the material is implied. This circumstance attracted the attention of the committee to whom our previous memoir was referred; and before it could be finally asserted that the kind of material has no influence upon the length of the punching, it was necessary to make a series of experiments upon different substances, in order to be assured that the lengths L would in every case confirm the numerical value obtained from the formula. We have experimented upon modelling wax, ceramic paste (wet and dry), tin, copper, and iron. The experiments were twenty-six in number.

In order to compare the results, we represented upon one figure all the ratios $\frac{L}{R}$, taking for abscissas the several values of $\frac{R}{R_1}$. The theoretic curve, whose equation is

$$\frac{L}{R_1} = + \log^1 \frac{R}{R_1},$$

was drawn to the same scale, so that it could be seen at a glance how the values $\frac{L}{R_1}$ agreed. This method, without exception, establishes the conclusion, that for all materials that can be punched, and in all cases in which the block is not so thin

that the punching reduces to a simple cleavage, the length of the punching is actually given by the theoretic formula, and the *a posteriori* verification allows us to affirm, with renewed confidence, all the principles of our theory of the deformation of solid bodies.

The measure of force necessary to effect the various punchings easily gives the value of the resistance to shearing, in case of the ordinary metals. This resistance (per square metre) is determined to be, for

Lead	1,820,000 kil.
Block tin	2,090,000 "
Alloy of lead and tin	3,390,000 "
Zinc	9,000,000 "
Copper	18,930,000 "
Iron	37,570,000 "

—*Les Mondes.*

ZINC-WHITE.—Within a very few years, zinc-white, or oxide of zinc, has become a favorite basis for a white pigment, and in many respects it has advantages over even the best white lead. For inside work and for localities whose atmosphere is more or less infected with sulphuretted hydrogen, it answers admirably well. In all respects it is certainly far superior to the highly adulterated white lead with which our markets are so abundantly stocked. Its use as a pigment in connection with any preparation of lead is, however, strongly to be deprecated, and the best way of applying it, according to Dr. Dingler, is the following: The ordinary boiled linseed oil should be substituted in the mixing operation by one prepared by gently boiling 200 lbs. of the raw oil for 5 or 6 hours, then adding about 24 lbs. of coarsely broken lumps of binoxide of manganese, and continuing the boiling operation for about 10 hours longer. In such a manner a very quickly-drying linseed oil is obtained, which is eminently fit for the purpose of being used with zinc-white and other zinc colors. The Doctor lays stress upon the use of old linseed oil, and also upon the care to be taken with the boiled oil, which, unless carefully kept from access of air, becomes thick in a very short time. The boiled oil so prepared ought not to be used in painting with zinc-white by itself alone, but should be mixed, in quantities of from 3 to 5 per cent., with the raw linseed oil used to mix up the paint.

THE USE OF MANGANESE COMPOUNDS in glass manufacture is one of the earliest applications of this element; but the fact that glass which has been bleached by it afterwards undergoes a marked change, and in the course of a few months has entirely different optical properties, is not generally known. The oxide of manganese is put in to counteract the effect of oxides of iron, but, in course of time, the oxide is acted upon by the light and air, and colors the glass red. Many a photographer has been puzzled to know why the glass of his skylight no longer lets light through so as to give him good pictures, and many a gardener has been troubled by the parched appearance of the grape vines in his conservatory, and by the decrease in the yield of grapes; both of these phenomena are due to the fact of the presence of manganese in the glass and the consequent red color. Red glass will not permit any chemical rays to pass, and hence the photographer can take no pictures. The same color will let heat through to parch and dry the vines, but the life-giving rays are cut off. Thus, as our knowledge increases, we must order our glass to be made according to the laws of light, as well as of chemistry.

OCEAN TELEGRAPHS.—The "Times" gives the following tabular statement of the ocean telegraphs now constructed or contracted for, and of the sums used or subscribed to complete them. Irrespectively of some short cables in the seas of Northern Europe, the list is as follows:

Name of Company, etc.	Capital.	Length of Cable.	When Contract was or is to be Completed.	Date of forming of Company.
		Miles.		
Anglo-American Telegraph Company	£1,360,000 ('65)	1,898	September, 1865	} March, 1865.
(Two Cables, Valencia to Newfoundland)	600,000 ('66)	1,852	July 27, 1866	
French Atlantic Telegraph Company, (Brest to Boston)	1,200,000	1,333	July 20, 1869	July, 1868.
Falmouth, Gibraltar and Malta Telegraph Company	660,000	2,456	May 31, 1870	July, 1869.
Anglo-Mediterranean Telegraph Company (Malta to Alexandria)	260,000	900	October, 1868	May, 1868.
British-Indian Telegraph Company (Suez to Bombay)	1,200,000	3,600	April, 1870	January, 1869.
British-Indian Extension Company (Ceylon to Penang and Singapore)	460,000	1,756	Before end of 1870	October, 1869.
China Submarine Telegraph Company (Singapore to Hongkong and Shanghai)	525,000	2,640	June 1871	December 10, 1869.
British-Australian Telegraph Company (Singapore to Java and Port Darwin)	660,000	1,726, 800 land	Before end of 1871	January, 1870.
Total capitals	6,925,000	20,961 —	Total miles.	

OIL OF VITRIOL.—A new method for effecting the concentration of oil of vitriol—the invention of M. Cotelle—is thus described in the "Journal de Pharmacie et Chimie." A column lined inside with fire-bricks and made outside of good ordinary bricks, rests on a large pedestal. This column is open at both top and bottom, but in these openings are fitted fire-clay stoppers. The inside is fitted with calcined pumice-stone; inside the lower portion, openings are made between the bricks,

through which a current of highly heated air is forced. From the top, the acid to be concentrated is made to trickle on the pumice-stone, and meeting with a current of highly-heated air, the superfluous water is driven off, and the acid, on arriving at the bottom, is in a concentrated state, and runs off in properly arranged vessels.

NATIONAL PROGRESS.—We give below an interesting table appended by Mr. Vignoles to the admirable address delivered by him before the Institution of Civil Engineers.

STATISTICS.

1868-69.	United Kingdom.	France.	Prussia.	Spain.	United States of North America.
Railways (English miles)	14,247	10,302	5,603	3,331	42,572
Metalled roads (English miles)	160,040	100,048	55 818	10,886	
Navigable rivers (do.)	.....	6,015			
Canals (do.)	3,000	3,154			
Telegraph lines (do.)	22,165	23,830	13,881	6,922	99,099
Telegrapn wires (do.)	96,104	67,473	45,708	15,263	
Telegraph stations (number)	2,432	1,701	830	184	
Post offices (number)	17,711	5,099	3,942	.....	25,200
Letters (number yearly)	808,118,000	537,099,358		.....	631,010,000
Newspapers and book packets (number yearly)	105,845,000	351,676,008	270,000,000	198,061	3,591,849
Area (square English miles)	122,519	210,460	139,675	15,673,481	38,442,995
Population (number)	30,621,431	38,192,064	23,970,941		

—*Engineering.*

THE REMOVAL OF BLOSSOM ROCK IN SAN FRANCISCO HARBOR.—The progress of perhaps one of the grandest engineering enterprises that has ever been conceived on the Pacific coast—the destruction of Blossom Rock—is rapid and steady. Our reporter visited the scene of operations on Sunday, and was courteously shown through the works by the gentleman in charge. The wooden structure which bears the engine and the shanty where a portion of the workmen reside has been so firmly secured to the rock and anchored on the outside that the high winds and swell on the bay have not affected it in the least, the water rushing though the open work beneath, with, even in the hardest gales, no perceptible vibrations to the occupants of this isolated dwelling. There are 16 men employed at present on the rock those engaged on the excavations below being practical and experienced miners. After being first provided with an oil-skin cap and sou'wester, the visitor descends the ladder placed on the side of the iron coffer dam, and, when stepping from the last round to the centre, from which the tunnels branch off, he finds himself 40 ft. below the level of the surface of the water. An iron pipe leads down to this well, through which the water resulting from the leakage of the shell of the rock is pumped up, and also a large tub and rope for the removal of the rock, both being worked by the engine on the scaffolding above. Here is a perfect network of tunnels branching off in every direction, and supported by the natural columns which are allowed for a short time to remain, but gradually replaced by powerful wooden stanchions. It is calculated that when the explosion takes place a small portion of the rock which may not be thrown upward or outward will fall back into the cavity, and therefore the rock has been excavated 9 ft. below the level required in the contract, and the columns are removed to make as much room as possible for the reception of this matter in the original shell. As the tubs of rock and rubbish are hauled up and dumped into the tide, the strength of the currents is sufficient to carry them off and distribute them so equally, as it were, that as yet, from the soundings, the mass has risen but 1 ft. above the natural level.

The area of Blossom Rock is 5,000 cubic yards, and 500 cubic yards have already been removed, a half yard being taken up in each tub. When the destruction of the rock was attempted by the Government by means of bursting torpedoes overhead, they succeeded only in cracking and perforating the rock, but not in displacing or separating any of the particles. In consequence of this, these portions of the rock where the experiments have been tried are so leaky that the workmen find its removal difficult. When tunnels have been excavated as far as possible toward the outward shell, twenty tons of powder will. inclosed in tight wooden casks, be distributed through these tunnels, the wire passing through all, and connected with a battery some quarter of a mile distant, so that the explosion must necessarily be simultaneous. The water will then be allowed to rush into and fill the coffer dam with an enormous pressure. There is but little doubt that the total annihilation of this dangerous obstruction to the freedom and safety of our harbor will be the result of the grand blast to come off about the middle of March. The residents on the rock have two pets which have become quite domesticated and attached to them. One is a seal, who paddles about the scaffolding all day, and appears to regard with interest the operations of the dumping machine; the other is a rat, who made the trip to the rock in a bag of coal, and who comes to the door of the shanty regularly at meal times. The latter animal is considered a lucky omen, for as rats never remain in a leaky vessel, the men feel quite secure in their house on the water, and say that when the hour of departure arrives the rat shall not be left to perish, but shall be safely landed on the wharf, to relate to his brother rats his experience on Blossom Rock. and the hospitable manner in which he was treated by their sworn enemies.—*San Francisco Bulletin.*

DETERMINATION OF THE MEAN ANNUAL TEMPERATURE. — Mr. Henry Lucas, in "Les Mondes," writes:

Forty years of observation have convinced me that a sufficiently exact determination of the mean temperature can be obtained by a single daily observation of the thermometer.

Let the temperature be noted at 8 o'clock in the evening, by a good thermometer, divided to $\frac{1}{5}$ or $\frac{1}{10}$ of a degree, properly hung, and it will be found that the annual temperature so obtained will agree almost exactly with that determined by making three observations in a day; and, besides, that the monthly averages are quite correct. The months of March and April, during 32 years' observations, give a difference of only 0.2 of a degree; for the other months the difference is $\frac{1}{10}$ of a degree and less. The monthly variations agree in this: that while the mean annual temperature calculated from observations at 8 o'clock in the evening, during 23 years, is 6 deg. 40 R., that which is deduced from three observations a day is 6 deg. 42 R.; a difference which is quite insignificant.

The observation of the thermometer at 8 in the evening has this great advantage over observations made at 6 A. M. and 2 P. M., that the effect of reflected heat is avoided.

The following table gives the mean temperature of 40 years' observations at 8 o'clock P. M., compared with the mean of temperatures observed at 8 A. M., 2 P. M., and 8 P. M.:

	8 P. M.		8, 2 & 8		Difference.
1823 to 1832..	6° 54 R.	..	6° 61 R.	..	0° 07
1833 " 1842..	6 54	..	6 54	..	0 00
1843 " 1852..	6 30	..	6 42	..	0 12
1853 " 1862..	6 17	..	6 20	..	0 03
Mean.....	6 39	..	5 44	..	0 05

Brandes, at Sazflau, from hourly observations during a year, gets a mean of 8 deg. 55 R.; from daily, at 8 P. M., a mean of 7 deg. 62. Kupffer, from 6 years of observations obtains a mean of 3 deg. 08 R.; from daily, at 8, a mean of 3 deg. 20. 11 years, at Schwerin, give a mean of 6 deg. 52; from daily observation at 8, a mean of 6 deg. 43.

DUALIN.—This compound, which, according to its inventor, Mr. Dittmar, possesses the explosive power of nitro-glycerine, together with the slow combustibility of ordinary gunpowder, consists principally of nitrate of ammonia and fine sawdust, that has been acted upon by nitro-sulphuric acid. This material, according to Fuchs, is undoubtedly endowed with a greater explosive force than ordinary powder; it is also considered as being less dangerous in regard to spontaneous explosion. In its composition it is similar to that of gun-cotton, being also subject to gradual decomposition in moist air. In regard to the efficacy of the dualin, as compared with dynamite (which is a mixture of nitro-glycerine and infusorial sand), the inventor states that they are both equal in this respect. However, it is extremely difficult to get at comparable results in blasting experiments; in most instances, the experimenter must be satisfied with the average results of a great number of trials undertaken under various conditions. But it is nevertheless easy, in one respect, to fix a difference between the two materials, which leaves no doubt as to the superiority of the dynamite. If equal quantities of dynamite and dualin, provided with primers, are allowed to explode upon air plates of equal strength, the effect indicates such an evident difference, that one must adjudge to the former a much more rapid and violent action. This will certainly be recognized in blasting rocks. In price dualin is cheaper than dynamite. When coming in contact with fire, it will certainly cause explosion, as it burns quite as rapidly as ordinary powder. Of the dynamite, however, it is sufficiently established that it will never explode on holding a flame near it, but simply burn quietly, even if inclosed in strong wooden boxes. Against pressure and concussions, both blasting materials are equally inert, and, finally, dualin possesses the advantage over dynamite that it does not freeze, while the latter, when in a frozen state, cannot be directly exploded. But as blasting is mosly suspended during frost, this circumstance is not of very great importance; moreover, the use of dynamite is not excluded at all, if frozen, as it will readily yield by the explosion of a small cartridge containing non-solidified dynamite. The great superiority of dynamite, above all, consists in its non-liability to become moist; this property allows its direct application under water and in bore-holes, while dualin, like gunpowder, does not bear contact with water.—*Journal of Applied Chemistry.*

TELEGRAPHIC COMMUNICATION WITH AUSTRALIA.—An apparently sound scheme for bringing the Australian colonies into telegraphic communication with the mother country has been introduced this week. It is to be styled the British Australian Telegraph Company (Limited), and is created in connection with the five companies by which the various sections that will constitute the great through line from England to the East have already been put in active progress. The present work is to consist of a cable of 563 miles from Singapore to Batavia, to join the Dutch lines which run to the south-eastern extremity of Java, whence another cable of 1,163 miles will be laid to Port Darwin in Australia, where a land line of 800 miles will connect the system with Queensland, New South Wales, Victoria, South Australia, Western Australia, and Tasmania. The capital is to be £660,000, in shares of £10, and the making of the entire lines is to be confined to the Telegraph Construction and Maintenance Company, at the contract price of £634,000, of which £120,000 is to be in paid up shares. The Falmouth and Malta, the Anglo-Mediterranean, the British Indian, and the British Indian Extension Companies are to allow the same rebate upon their through rates on all messages forwarded over their route by this company as they have granted to the China Submarine Company, thus creating a reciprocity of interests calculated to operate as a strong inducement to the harmonious working of all. According to the prospectus, the estimate of profit, reckoning 25 daily messages from the Dutch islands, and but 65 from the whole of the Australian colonies, is £121,665, or about 18 per cent. per annum, exclusive of local and Chinese traffic, and should this be steadily realized it may be hoped the directors will have the wisdom thenceforth to preclude all chance of future competition by giving their customers the benefit of a constant reduction in charges in proportion as any increased success may be attained.—*Engineering.*

LIVERPOOL TO BOMBAY, *via* THE SUEZ CANAL.—At present the public and also commercial men are anxious to know the real value of the

Suez Canal, either in a financial point of view or in the saving of time in the transmission of goods between England and Bombay. The following figures, which have been compiled by one of the officials connected with the Liverpool Chamber of Commerce, will be read with considerable interest. From this statement it appears that at the opening of the canal last year, the rate of freights from Liverpool to Bombay, *via* the canal, was 80s. per ton, but at the present time freights by the same route do not exceed 30s. per ton, overland rates being about the same. No sailing vessels, it appears, convey goods either *via* the Suez Canal or overland route, and the following quotations are consequently for steamers alone: Sailing vessels.—Average duration of voyage to India—*via* Cape of Good Hope, 95 days; *via* overland route, 43 days; *via* Suez Canal, 38 days; to the United States, 40 days. Steam vessels.—Average duration of voyage to India—*via* Cape of Good Hope, 60 days; *via* overland route, 43 days; *via* Suez Canal, 38 days; to the United States, 12 days. Sailing vessels.—Average rate of freight per ton to India—*via* Cape of Good Hope, 35s.; *via* overland route, 80s.; *via* Suez Canal, 40s.; to the United States, 10s. Steam vessels.—Average rate of freight per ton to India *via* Cape of Good Hope, 60s.; *via* overland route, 80s.; *via* Suez Canal, 40s.; to the United States, 30s.—*Liverpool Albion.*

EMERY.—The quantity of emery used in this country, already very large, is increasing annually. One house in Boston, D. Webster King & Co., of 51 Kilby street, sells the entire product of one factory, which turns out about 1 ton per day. The main building is 60x30 ft. and 3 stories high, with an ell attached 50x30 ft. Here are employed about 12 men in the manufacture of Smyrna emery from the pure Turkish stone. The different grades are 24 in number, and to produce these the stone has to pass through a large number of crushers, rollers, bolts, cleansers, etc. Four large elevators run from the ground floor to the 3d story, besides several other smaller ones. The finest grade of emery is produced by what is called a blower, which was devised by the company. This grade, which is called the flour of emery, floats in the air in a large room through the day, and when work in the mill ceases over night it becomes settled. The great advantage which this company claim over all others is their machinery, which gives a perfect grading, and cleanses the same in the very best manner. The company are constantly receiving this stone from Turkey. For polishing hard minerals and metals it has no equal. It is a subspecies of rhomboidal corundum, and occurs in massive and also in granular concretions. Its color is between grayish black and bluish gray, and when powdered it has a reddish hue. It is so very hard as to scratch topaz, its constituents being alumina, silica, and iron. The mill has been in operation 3 years. The company have now a capital of $200,000, and are doing a thriving business. D. Webster King & Co., 51 Kilby street, Boston, are agents for the company.—*Chicago Railway Times.*

THE WATER SUPPLIES OF LONDON AND PARIS.—The quantity of water supplied daily to the metropolis during the year has ranged from 91,578,341 gallons, in the month of January, to 110,094,058 gallons, in the month of July; the average for the whole year being, as nearly as possible, 92,000,000 of gallons daily; and the average number of houses supplied has been 466,100. This is at the average rate of 29 gallons per head of the population daily. About half of the supply is from the Thames, and the rest is from the River Lea and from springs and wells in the chalk. According to the official returns from the Prefect of the Seine, the average daily supply of water to Paris during the year has been 46,858,900 gallons, which is at the rate of 24.8 gallons per head of the population; but this includes the supply to the public fountains and to the ornamental waters in the Bois de Vincennes, the Bois de Boulogne, and elsewhere. The water is derived from the Seine, the Marne, the Canal d'Ourcq, and from artesian wells and springs in the chalk. None of the river water is filtered, and it is always turbid.—*Engineering.*

SPECTRUM OF THE FIRE-FLY.—Professor C. A. Young says this is "perfectly continuous, without trace of either bright or dark lines, and extends from a little above Fraunhofer's line C, in the scarlet, to about F in the blue, gradually fading out at the extremities. It is noticeable that precisely this portion of the spectrum is composed of rays, which, while they more powerfully than any other affect the organs of vision, produce hardly any thermal or actinic effect. In other words, very little of the energy expended in the flash of the fire-fly is wasted. It is quite different with our artificial modes of illumination. In the case of an ordinary gas-light, the best experiments show that not more than one or two per cent. of the radiant energy consists of *visible rays;* the rest is either invisible heat or actinism; that is to say, over ninety-eight per cent. of the gas is wasted in producing rays that do not help in making objects visible."

EJECTOR CONDENSERS.—The most important improvement that has lately been made on steam engines in general, is the introduction of apparatus whereby the combined impetus of the currents of exhaust steam and of injection water is made use of to eject the product of condensation, and so to supersede the air-pump, well-known to be one of the most troublesome parts of the steam-engine. This enables condensation to be used in many engines in which it was never applied before: such, for example, as the small separate engines now often used in factories to drive various machines, instead of the former system of transmitting power by lines of shafting; and it possibly may have ultimately the effect of putting an end to the use of non-condensing engines, except where the exhaust steam is needed in order to produce a blast.—*W. J. M. Rankine.*

MELENE AS A LUBRICATOR.—An insuperable difficulty attending the use of ordinary lubricators, is their decomposition at high temperatures, leaving behind a thick viscid coating which, especially in cylinders, interferes considerably with the motion it should assist. Ericsson's hot-air engine is especially difficult to lubricate, from this cause. The use of "melene" is advised for this purpose; it being a substance obtained from the paraffines, insoluble in water, soluble in the fixed oils, volatile without decomposition, not boiling under 370 deg., of the consistency of wax at ordinary temperatures, and floating on the surface of cold water. It is cheap enough to be used on a large scale, and preserves from oxidation and adhesion.

THE BESSEMER FLAME SPECTRUM.

Fig.1 Spectrum of the sun.

Fig.2. Spectrum of the Bessemer flame.—Bielegg.

Fig.3. Manganese spectrum (with the sodium line)

Fig.4. Bessemer spectrum.—Watt.

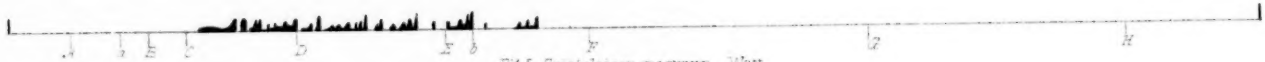


Fig.5. Spiegeleisen spectrum.—Watt.

Fig.6. Iron spectrum.—Thalèn.

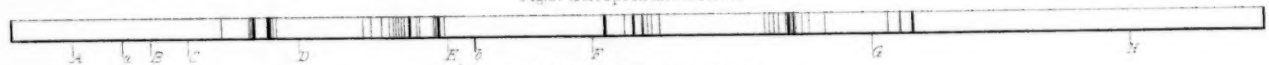


Fig.7 Manganese spectrum.—Huggins.

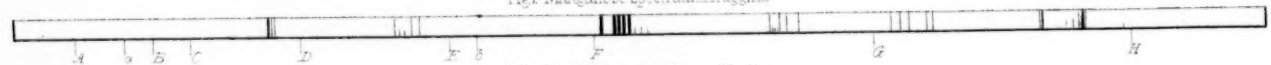


Fig.8 Manganese spectrum.—Thalèn.

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